SCIENTIFIC AMERICAN SUPPLEMENT. No 1545

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Scientific American, established 1845.
Scientific American Supplement. Vol. LX., No. 1545.

NEW YORK, AUGUST 12, 1905.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.

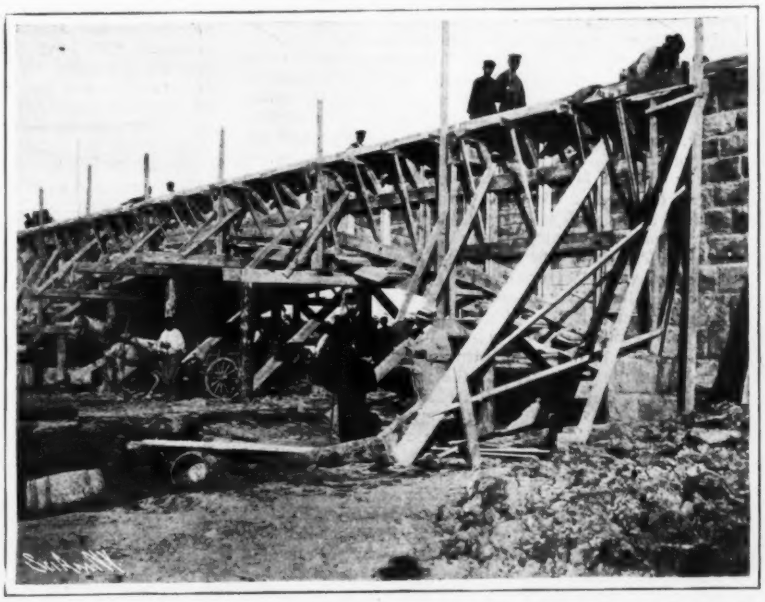
STRIKING THE CENTERS OF THE FIRST THREE SPANS.

END OF THE CONCRETING OF THE THIRTEENTH SPAN.

THE CENTERING OF THE LAST SPAN.

VIEW OF THE TOP OF THE BRIDGE AND THE SERVICE TRACK.

VIEW OF THE UPPER PART OF THE FIRST SPAN FROM THE RIGHT SHORE.



DETAILS OF WOODWORK USED IN CONSTRUCTING THE THIRTEENTH SPAN. THE GUARD RAIL IS PLACED UPON THE TWELFTH SPAN.

THE KAZARGUENE BRIDGE. THE LONGEST BRIDGE IN THE WORLD CONSTRUCTED OF REINFORCED CONCRETE.

THE KAZARGUENE BRIDGE.*

By L. Ramakers.

The road from Verder to Revel, government of Esthonia, Russia, crosses, at the village of Kazarguene, a river of the same name, which, at this point, offers a ford that is passable at low water. During the freshets that occur after somewhat heavy rains, a horse-ferry establishes a communication between the two shores; but, in winter, when the ice is not sufficiently strong, and especially during the entire period of the breaking up thereof, communication between the two shores is completely interrupted. Hence arose the necessity of establishing a bridge.

During high water, the discharge of the river is considerable, and the level rises 7.5 feet above low-water mark, and, since the banks are low, the country becomes flooded over a vast area.

Although the river is not navigable, it was decided to give the projected bridge a length of 985 feet, exactly 977 feet between the abutments. As the result of a competition, the work was awarded to the firm of Monicourt & Egger, general Russian agents for the Hennebique system, which offered the most favorable conditions.

The project presented and approved comprised 13 arch spans, each of 75.5 feet opening, resting upon 12 masonry piers of granite, and one of ordinary concrete; the facings of the two abutments being of granite. The width of the bridge is 23 feet, including a paved roadway 17.5 feet wide and two sidewalks of 2.75 feet each.

The bridge is calculated to carry, in addition to its own weight and that of the paved road, an overcharge of 90 pounds to the square foot. The calculations also provided for the possible passage over the road of a 15-ton steam roller.

Each span of the bridge comprises three arches of reinforced concrete. The arches rest upon the masonry of the abutments through the intermedium of a strong sill of reinforced concrete of which the lower part is inclined in a direction at right angles with the thrust, the point of application of which is at the center of the height of the inclined part of the sill. This latter is so calculated as to distribute the load uniformly over the surface of the abutment. The weight of the abutment and filling is sufficient to assure stability under good conditions, without taking into account the supplementary support given to the rear of the abutment by the filling in of the road.

The arches rest upon the piers through the intermedium of a horizontal sill of reinforced concrete covering the entire surface of the pier between the arches. A vertical web placed in the axis of the pier and forming part of the sill cross ties the lower parts of the arches. The surfaces of the sills are so established as to stand a maximum overload of 110 pounds to the square inch upon the masonry.

The surfaces of the foundations of the piers and abutments are so calculated as to give a maximum load of 47 pounds to the square inch upon the ground, this being admissable in view of the fact that the subsoil at 6½ feet below the bed of the river consists of very hard clay mixed with pebbles. The foundations are generally established at this level.

The three reinforced concrete arches of each span have a pitch of 1/10 of the span, say, 7 feet. The middle arch has a section of 12 inches in height at the key and a width of 10. The arch continues to spread as far as to the springings, where it has a width of 18 inches. The lateral arches have a constant thickness of 10 inches. The three arches have the same *intrados*. Girders of reinforced concrete of 8 x 10 inches spaced 10¾ feet from axis to axis, are arranged at right angles with the arches, and, with the latter, carry the superstructure of the bridge, which is 4¾ inches in thickness. The cross girders are prolonged externally to the lateral arches and form supports for the sidewalks. These latter, which are raised above the road, are 4¾ inches in thickness, and are calculated for a uniformly distributed load of 90 pounds to the square foot. They are paved with slabs of cement.

The side rail is of iron, and is simple and strong. At every 6½ feet it is sealed into a pillar of reinforced concrete standing in the plane of the axis of the piers. These pillars break the monotony of the line of side rails, which latter are prolonged upon the abutments, where large pillars mark the entrance to the bridge.

For half of its length the bridge has two inverse slopes of 1/5 of an inch to the yard that unite at the middle span, which is the highest. The water thus flows from the center of the bridge toward the two banks. The paving of the bridge is arranged with the usual convexity in order to direct the water toward the sidewalks. The superficial water flows through the superstructure of the bridge through the intermedium of twelve cast-iron gratings sealed in the concrete. The water of infiltration flows through 26 iron tubes imbedded in the concrete, and the mouth of which is at the level of the top of the concrete of the bridge superstructure.

The concrete designed for the reinforced concrete work, and consisting of gravel, sand, and Portland cement, was prepared at the level of the ground in a vertical concrete mixer actuated by a portable steam engine. At its exit from this the concrete was placed in a car box which, after being filled, was hoisted to the level of the bridge superstructure by means of a windlass actuated by the engine. At this level the box was placed upon the truck of a car and taken to the working point. For this purpose, a wooden foot bridge connected the hoist with the abutment. Upon this foot bridge there was laid a track, with a shunt permitting of the running in each direction of the full and empty cars. The railway was afterward prolonged upon the bridge itself in measure as the work progressed. The superstructure, about twenty-four hours after its completion, received a stratum of sand designed to protect it against the direct action of the sun, and forming a ballast for the car tracks.

The starlings, which are of reinforced concrete, have the form of a carapax covering the front of the piers. Their edge is inclined at an angle of 45 degrees and provided with an angle iron sealed in the concrete and designed to receive the impact of the ice. The removal of the wooden walling of the rubble work, cross-girders and sides of the arches was effected as the work progressed, and the wood was carried to and re-employed in the new spans. As the somewhat high temperature favored the rapid hardening of the concrete, it was found possible to remove the wood at the end of twenty days and sometimes sooner. The centerings placed directly under the arches were, along with their props, allowed to remain longer in place. The props placed near the piers were removed first in order to permit of the work of junction, and of the filling in around the piers.

The presence of the centerings in no wise prevented a moving about on the bridge, which, however, was at once utilized by the contractors for the carriage of the materials designed for the paving.

The pitches were observed at the striking of the centerings by means of an amplifying apparatus actuated by a wooden rule fixed to the summit of the arches. The pitches observed were 1-42,600 of the span.

The work was entirely established and calculated according to the principles of construction and methods of calculation of Engineer Hennebique, of Paris. It is, if not the longest work in reinforced concrete (the Simplon aqueduct is 9,840 feet in length, and the Borgone aqueduct 4,590), at least the longest reinforced concrete bridge now in existence, so far as we are aware.

It offers an aspect of extreme lightness, and despite its simplicity, not to say absence of decoration, it is, by reason of its lines alone, extremely elegant. It was tested by the addition of an immovable overcharge, and also as to its resistance to shock. The first overcharge test was made by means of a layer of sand and gravel uniformly distributed over the entire surface of the bridge and sidewalks, the overcharge covering the second and third span reckoning from the right shore, and having as a value the normal load of 90 pounds to the square foot. The distortions of the arches were measured by means of wooden rules. The maximum pitch ascertained was 1-7,000 of the span. The rules placed in the middle of the arches of spans 1 and 4 indicated a maximum sheer of 0.39 of an inch.

In the presence of these remarkable results, the commission raised the overcharge upon half of the third span and distributed it over the second, which remained charged. This latter was thus overcharged one and a half times more than the normal, while the third span was charged asymmetrically upon half of its length. The rules of span No. 1 indicated a maximum sheer of 0.78 of an inch, say 1-4,700 of the span. This overcharge was left upon the bridge for about fifteen hours, and, after the removal of it, the arches righted themselves and the maximum permanent pitch ascertained was less than 1-6,000 of the span.

The tests in the matter of shock consisted in permitting of the fall, from a height of eight feet, of a barrel of 333 pounds to the middle of the panel of superstructure, and then of two barrels of the same weight falling together from the same height. The maximum amplitude ascertained under the shock was less than 0.39 of an inch.

* Specially prepared for the Scientific American Supplement.

ALCOHOL IN GERMANY.

HOW MANUFACTURED AND USED.

Consul-General Mason, of Berlin, Germany, in the annexed communication corrects some erroneous impressions that have been created in this country regarding the materials used in Germany for the manufacture of alcohol for industrial purposes. The consul-general also contributes interesting facts regarding the use of alcohol for motor and industrial purposes. He writes:

From the number of inquiries which have been received recently at this consulate and which seem to have been inspired by press statements published in the United States, it is apparently believed there that alcohol for industrial uses is manufactured in Germany from peat, street garbage, and various other materials, and that the use of alcohol as fuel for motors, especially for automobiles, has been recently begun and is rapidly increasing to vast proportions in this country.

In reply to all these inquiries it may be said that alcohol is not made on an industrial scale in this country from peat or from garbage of any kind. Aside from the small amount that is produced for drinking and medicinal purposes from prunes, grapes, cherries, and other fruits, the great sources of alcohol for industrial and other uses are potatoes, grain, and the molasses derived as a secondary product from the manufacture of beet sugar. From the official statistics of the last year's campaign (September 1, 1903, to August 31, 1904), the following figures are derived, which show the total production of alcohol from each of the three materials during the year, in hectoliters of 26.429 gallons each: Potatoes, 3,045,605; grain, 692,483; beet molasses, 116,211; total, 3,854,299 hectoliters (101,823,470 gallons).

AS A MOTOR AGENT.

In respect to the use of alcohol for motor purposes, the following are the obvious facts:

Several years ago, when the motor vehicle for military and industrial purposes began to assume a new and extraordinary importance, the German government became impressed with the necessity of building motors which could be operated with some liquid fuel that could be produced in Germany, in the event that through the chances of war or other cause the supply of imported benzine and other petroleum products should be cut off. Alcohol offered the solution of this problem, and all the influence of the Government was exerted to encourage its production and its more extended use for motor purposes. Prizes were offered for the best alcohol-driven draft wagons for military and agricultural purposes, and all the great gas-motor builders gave great attention to perfecting engines specially adapted to the use of alcohol as fuel.

At the same time a powerful organization known as the Centrale für Spiritus-Verwerthung, with central offices at Berlin and branches throughout the empire, was established, and began a systematic, persistent campaign to encourage and extend the use of alcohol for various industrial and economic purposes, especially heating, cooking and lighting. Special exhibitions were held from year to year, which have been fully described in these reports, and in which were displayed the whole apparatus and process of alcohol production from potatoes, corn, and molasses, motors of various types and sizes for marine, agricultural, and industrial purposes, and a vast assortment of alcohol stoves for heating, cooking, ironing, etc., and lamps and chandeliers in endless variety in which alcohol vapor, burned inside an incandescent mantle, produced a light of high intensity and cheaper for rural districts of Germany than either electricity or petroleum.

The net result of all this systematic effort has been to extend so rapidly the use of alcohol for heating, lighting, and chemical manufacturing purposes that when the drought of last summer reduced somewhat seriously the output of potato alcohol, the previous surplus was exhausted and the price advanced until alcohol became too costly for economical use as fuel for motors.

ALCOHOL FOR INDUSTRIAL PURPOSES.

The consequence of all these conditions has been that while the general use of alcohol for industrial purposes, heating, lighting, and a vast range of chemical and other manufacturing purposes has steadily increased in Germany, the percentage of the whole product that is used for motor purposes is relatively small and, so far from increasing, is said to be rather diminishing, though to just what extent it would be difficult to prove. A few Germans, from patriotic motives, use alcohol for driving automobiles, freight wagons, motor boats, and farming machinery. A single department store in Berlin, which ordered its equipment of delivery wagons four years ago, during the height of the alcohol-promotion movement, still consumes yearly 80,000 liters (about 19,000 gallons) of alcohol for driving these wagons, but mixed, for greater efficiency, with about 15 per cent of benzole.

It has been found by elaborate tests that the economy of alcohol as a fuel for gas motors is largely increased by its being carbureted through admixture with a certain percentage of benzole or other product of mineral oil. For a time it was believed that this admixture of benzole could not be safely carried beyond 20 per cent, but more recent experience has shown that a mixture of equal parts of alcohol and benzole can be used, especially in large motors, with entire safety and economical results. For automobile purposes the usual proportion is now about 30 per cent of benzole or gasoline, but at the present cost of alcohol it can not compete on the score of economy with mineral hydrocarbons in a country where they are either produced or imported free of duty.

There are now in use in Germany something more than 2,000 stationary or portable alcohol engines, exclusive of the spirit motors used in automobiles. They consumed in the campaign year 1903-4 36,000 hectoliters (951,120 gallons) of denaturated alcohol. Owing to the enormous potato crop of 1901 and the consequent overproduction of alcohol, the denaturated spirit of the grade used for motors could be bought in 1902-3 in any quantity for 15 to 17 cents per gallon, but for reasons hereinbefore stated this price rose in 1904 to 35 marks per hectoliter (about 31.5 cents per gallon), at which figure it became more expensive as motor fuel than gasoline.

Such is substantially the situation in Germany. The manufacture and industrial uses of alcohol were never so great, so important, and so varied as now. This general increase in the campaign year 1903-4, compared with the preceding year, was, according to the annual report of the Centrale, more than 2,900,000 gallons. But notwithstanding the fact that all the leading German manufacturers of gas engines and motor vehicles make alcohol motors that are technically successful, the question of price is the controlling consideration, and of the whole 3,854,299 hectoliters (101,823,470 gallons) of spirits produced during the last campaign year only about 1 per cent was used for motor purposes.

The importance of testing rocks to be used in road building is being recognized at the present time by the leading highway engineers of the country, and a number of laboratories modeled after the Agricultural Department's Road Material Laboratory have been established in different places.

THE PROPERTIES OF MAGNETS MADE OF HARDENED CAST IRON.*

By B. O. Peirce.

During the last six or seven years a large number of d'Arsonval galvanometers, in which the permanent fields are due to hardened and artificially seasoned cast-iron magnets, have been used in the physical laboratory of Harvard University in competition with similar instruments furnished with hardened forged-steel magnets from the shops of well-known makers. For nearly five years also magnets of the same kind have been employed in standard mirror ampere-meters and voltmeters fixed in the laboratory, in cases where it was desirable that the indications of the instruments should be trustworthy within one part in a thousand of their larger deflections, over a considerable range of room temperatures. Besides the cast-iron magnets which we have made ourselves, we have of late used a number of others in moving-coil galvanometers purchased in the market—some of the best of them from the Leeds & Northrup Company.

It early appeared from tests made on these instruments, that whereas good iron castings as they come from the foundry make most unsatisfactory magnets, so far as permanence is concerned, magnets made of castings properly hardened and aged after being machined—if machining is necessary for the purpose to which the magnets are to be put—compare favorably in strength, in permanence, and in the relatively small changes of their moments with room temperature, with the best of tool steel magnets, even if in strength, though not in their other qualities, they fall a little behind magnets made, in a forming press, of steel specially prepared for the purpose.

Although chilled cast-iron bar magnets have been used for a long time in a few forms of telephones, it is usually best to make straight magnets (which do not need to be hammered) of steel; but the forging of steel for permanent magnets of complex forms, without spoiling it, demands a kind of skill which most toolmakers, even in the largest establishments, have not acquired, and it is generally difficult to get satisfactory specimens of any very special shape of curved-steel magnets unless one has access to such facilities as a few of the manufacturers of electrical measuring instruments have provided for themselves. It is true that the hardening of iron castings for magnetic purposes also requires such skill as few persons possess, if the very best results are to be obtained, especially when the pieces to be treated weigh more than a pound or two; but a little practice will enable any good workman, who has a gas forge with blast powerful enough to raise the temperature of the iron uniformly nearly to the melting-point, to make good gray-iron castings of moderate size, hard enough for strong magnets, which will leave little to be desired so far as permanence is concerned. It has been my good fortune to have the help of Mr. G. W. Thompson, the mechanician of the Jefferson Laboratory, who has had long experience in treating cast iron, and who has made for me, by a process of his own, massive magnets with extremely low temperature coefficients. It is to be noticed that some of the secret methods of hardening cast iron, used by makers of small parts of machinery, do not fit the castings for making good magnets, and that case hardening, which affects the surface only, is useless. The character of the cold bath into which, while it is kept in violent agitation, the strongly heated castings to be hardened are plunged, seems to have considerable influence upon the result.

At the very high temperature, just under the melting-point, to which the cast iron must be raised before it is suddenly chilled, the metal loses much of its tenacity, and slender pieces must be handled carefully lest they break like chalk. The chilled casting should be hard enough to scratch window glass, if not so readily as hardened tool steel will do it. It is vain to attempt to make any such gray-iron castings as I have used magnetically hard by chilling them after they have been heated to the comparatively low temperatures that one would use in making steel glass-hard. Every one who has attempted to harden a thick mass of tool steel uniformly, knows how difficult the task is: it is easy enough to get the outer layers glass-hard, while the interior is much softer; or, sometimes (by overheating the steel), to get the inside hard while the outside is blistered and cracked. If a casting is heated to a very bright red and then plunged into the bath, the outside may become hard to the file, while the interior, as magnetic tests clearly show, remains soft; in this case, however, the material will stand a higher temperature without injury, and if the mass be reheated and when it is just below the melting point be suddenly chilled, the whole interior becomes hard.

It is a good deal easier to harden a lot of straight, round pieces of good gray iron, say twenty centimeters long and one centimeter in diameter, so that they shall all be nearly alike magnetically, than it is to do the same with an equal number of pieces of drill rod. Six pieces of Crescent drill rod, each sixteen centimeters long and eight millimeters in diameter, cut from the same specimen, were made glass-hard for me by a skilled worker in steel; these were placed successively in a properly oriented solenoid and exposed, first to the action of an alternating current of intensity gradually decreasing from an initially high value to a very low one, then to a steady field of 147 gausses applied first in one direction and afterward in the other. As a consequence of the preliminary treatment† with alternating currents, the magnitudes of the moments acquired by the pieces under the action of the steady field were quite independent of the direction of the latter. These moments were approximately 2,280, 2,395, 2,495, 2,326, 2,325, and 2,360, but when the field was removed the residual moments were 1,058, 1,074, 1,136, 1,066, 1,050, and 1,097 respectively. The same pieces were then placed together in a solenoid made of many turns of large wire and the ends of the whole bundle were connected by a massive yoke; when a current of about forty-five amperes was sent through the wire the pieces became charged practically to saturation. When they were removed from the solenoid the average moment of the six was about 1,240, the highest 1,290, and the lowest 1,170. Such uniformity as is indicated by these numbers is, I believe, as great as one can expect to get unless one has an elaborate plant; no such agreement can be hoped for from pieces of different rods of the same brand. Some kinds of special magnet steel give rather better results.

Although it is obvious that there is no advantage in using cast iron for straight magnets, I have had a number of such magnets made, of each of three shapes, for purposes of comparison with steel-bar magnets of the same dimensions. These were all rather short, because we had no means of treating satisfactorily very long, slender pieces, which are apt to warp if not properly supported. It is, of course, impossible to calculate the demagnetizing effects of the free ends of such pieces as I have used, but it has seemed to me legitimate to draw some inferences from the hysteresis curves and from the temperature coefficients of rods of different materials if they are geometrically alike.

Most of my experiments on the strengths of round cast-iron bar magnets have been made with pieces eighteen centimeters long and either 0.95 centimeter or 1.25 centimeters in diameter, of which I have a good many, some new and some cast two years ago. These were usually relaxed* after their hardening by being boiled in water for some time; next they were magnetized to saturation in a solenoid, and then they were again boiled and "aged" in the usual manner. The resulting magnets were finally tested in competition with a large number of seasoned tool steel magnets, of different brands but all of the same dimensions as the castings, with the help of a mirror magnetometer. The cast-iron magnets looked, of course, rather rough in comparison with others made of polished rod; but their moments differed among themselves less than those of an equal number of the steel magnets made of any one brand. Just one of the tool steel magnets had a moment sensibly greater (about four per cent) than any of the cast-iron magnets, but the average of the moments of the cast-iron magnets was rather greater than those of the steel, even after the records of the two or three steel magnets with abnormally low moments had been rejected.

Two years ago† I measured the temperature coefficients of a good many bar magnets of cast iron and steel. In every instance, as was to be expected, the rate of loss of moment per degree of rise of temperature was much greater at temperatures near the boiling-point of water than at room temperatures, but if for purposes of comparison we used the mean loss, per degree, of the magnetic moment, when the magnet was heated from about ten degrees centigrade to 100 degrees centigrade expressed in terms of the moment at the lower temperature, it appeared that in the case of rods sixteen centimeters long and 0.95 centimeter in diameter these mean losses were:

0.00042 for seasoned, chilled cast-iron magnets;

0.00046 for seasoned magnets made of Crescent steel drill rod;

0.00046 for seasoned magnets made of Jessop's round black tool steel;

while they were

0.00070 for seasoned magnets made of Jessop's square tool steel sixteen centimeters long and of cross-section nearly that of the round rods.

In the case of shorter rods the difference was still more in favor of the castings because, I suppose, they were more uniformly hardened in the interior than the steel could be.

If an iron casting which has been hardened and boiled is magnetized in a solenoid either to saturation or to a degree which falls much short of this, it is practically impossible to decrease the moment by even so little as a tenth of one per cent, by striking the magnet on end with a wooden mallet or with a stone. I have tested many such magnets by dropping each two or three hundred times upon a stone slab, or by giving it hundreds of sharp blows with wooden clubs; the magnets get a little warm during this harsh treatment, but when their temperatures again fall to the original point the moments, which may have fallen a small fraction of one per cent, regain wholly, so far as my observations go, their old values. Some few of the specimens of special magnet steel that I have examined are nearly equal to the castings in this respect.

Prolonged boiling has, however, always reduced the moment of the cast-iron magnets very sensibly, and this loss may be as much as twenty per cent when the magnetizing field has been an extremely strong one and the residual moment is very high; if the casting has not been magnetized to saturation, the loss of moment by boiling is much less. If, after a cast-iron magnet has been seasoned, its temperature be suddenly raised from room temperature to 100 deg. Centigrade, and then as suddenly lowered, the magnet may not wholly recover its original strength until after the lapse of several hours; if, however, the upper limit be only 50 deg. Centigrade, there seems then to be no sensible lag in the attainment of the whole of the original moment after the testing.

*Abstract of paper presented at a recent meeting of the American Academy of Arts and Sciences.

†J. A. Ewing, "Magnetic Induction in Iron and Other Metals," 1892, p. 28.

* Barus and Strouhal, Bulletin of the U. S. Geological Survey, No. 14, 1885

† Peirce, Proceedings, American Academy of Arts and Sciences, February, 1903.

NOTE ON A SIMPLE DEVICE FOR FINDING THE SLIP OF AN INDUCTION MOTOR.*

By Charles A. Perkins.

There are a number of devices for finding the slip of an induction motor; but the following device, adopted more than a year ago in the laboratory of the University of Tennessee, is more simple and inexpensive than any other accurate device known to the writer. It does not even require the contact-maker and voltmeter described by B. F. Bailey in the Electrical World for April 22, 1905.

The device consists of a strip of sheet-iron, clamped at one end to an iron base, leaving the other end free to vibrate. An electromagnet is mounted on the same base with its pole near the free part of the strip. When an alternating current is passed through the electromagnet, in series with one or more lamps, the strip will be thrown into vibration, if it has about the same period of vibration as the driving current. The adjustment of the time of vibration of the strip is readily made by giving it such a length as shall cause it to vibrate a little too rapidly and then loading it by a small copper wire which may be slid along the strip until approximate synchronism is obtained.

On the shaft of the motor is placed a cardboard disk, pierced by as many equally-spaced holes as there are north poles on the motor. The iron strip, with the electromagnet, is now placed in a good light and set into vibration by the supply current, and viewed through the holes in the rotating disk. If the hole comes at each revolution in front of the eye when the current is in a certain phase, the vibrating strip will also be in the same phase at each view, and will apparently be standing still. As the motor slips backward, the strip is seen at successively later phases of its vibration, and seems to be slowly vibrating, making one complete vibration when the motor has lost one complete cycle. By this method the slip may be counted up to about 300 cycles per minute, serving for all cases excepting for small motors with heavy loads, or on high-frequency currents.

The holes in the disk may be of generous size. In the disk that the writer is using, they have a diameter equal to about one-eighth the circumference of the disk, without troublesome blurring; therefore it is easy to view the strip from a convenient distance, without stooping to the level of the disk. The frequency of the supply current may be taken from the speed of the motor, adding the correction for the slip; or if the iron strip is provided with a definite sliding weight whose position is calibrated for different periods of vibration, as described by Kinsley in the Physical Review for April, 1899, the frequency of the supply current is read off directly from the position of the slider, and the speed of the motor is then found from its slip. This requires a more careful adjustment of the slider and the use of a weaker current in the electromagnet, so as to avoid producing a forced vibration of the strip.

It is possible that a strong current in the electromagnet may reverse the magnetism of the core, giving the strip a period of vibration double that of the current. If the ear cannot decide from the pitch, a disk may be placed on the motor-shaft, having twice the number of holes. If the image of the strip is still clear, the vibration is double the frequency of the current.

The rotating disk on the shaft of the induction motor is a convenient device for producing a number of stroboscopic effects. Thus, if an alternating arc is projected on a screen through the holes of the disk, the arc is observed to go through all its different phases. The brightening of the poles during the maximum and their cooling during the minimum are conspicuous. A soft cored carbon has a bright point on the hard shell during the positive maximum, and a lighting up of the core at the negative maximum. The arc nearly or quite dies out in the case of a hard carbon, while with a low-tension flame carbon the arc simply changes a little in size. Of course these changes may be used for counting the slip of the motor, but the motion of the iron strip is usually more convenient.

MOTOR BOATS AND HERRING FISHING.

The question of auxiliary power to sailing vessels has become one of increasing importance. In the Shetland Islands, says Mr. Consul Villiers, in his report on the Faroe Islands for 1904 (No. 3404, Annual Series), it has been declared vitally important for the herring fishing. A benzine motor boat has been plying among the islands for some time, but petroleum motors are now chiefly attracting public attention. More than one fishing smack has already been satisfactorily supplied with a petroleum motor, giving a speed of six or seven knots. The first was a vessel of about 50 tons. Smacks are thus enabled to enter harbors promptly with their catch, and leave again at will for the fishing banks, without waiting for the chance of a favorable breeze and not too strong a current. A telegraphic cable is about to be laid from the Shetland Islands to Faroe and Iceland, and will be open for public service on October 1, 1906. Telegraphic communication will be of much service to British

* A paper presented at the Twenty-second Annual Convention of the American Institute of Electrical Engineers, Asheville, N. C., June 19-23, 1905.

fishing companies since it is very important to them that their vessels should not be entirely isolated, especially in case of wreck or breakdown, and the cable must materially assist in the development of the growing fishing industry. Prices will be quoted, and vessels will know when and where to sell their fish to the best advantage, instead of sailing vaguely hence as now.

THE STEAM TURBINE AS APPLIED TO ELECTRICAL ENGINEERING.*

By the Hon. Charles A. Parsons, F.R.S.; G. Gerald Stoney, and C. P. Martin.

In the early days of electric lighting the speed of dynamos was far above that of the engines which drove them, and therefore belts and other forms of gearing had to be resorted to. To make a high-speed engine, therefore, was of considerable importance, and this led to the possibilities of the steam turbine being considered. It was, however, at once seen that the speed of any single turbine wheel driven by steam would be excessive without gearing, and in order to obtain direct driving it was necessary to adopt the compound form, in which there were a number of turbines in series, and thus, the steam being expanded by small increments, the velocity of rotation was reduced down to moderate limits. Even then, for the small sizes of the dynamos at that time in use, the speed of revolutions was high, and therefore a special dynamo had to be designed. Speaking generally, an increase of speed of a dynamo increases its output, and therefore it was obvious that such a high-speed dynamo would be very economical of material.

These considerations led, in 1884, to the first compound steam turbine being constructed. It was of about 10 horse-power and ran at 18,000 revolutions per minute, the diameter of the armature being about three inches. This machine, which worked quite satisfactorily for some years, is now in the South Kensington Museum.

Before, however, this first turbo dynamo was constructed, a set of preliminary experiments were commenced at Gateshead-on-Tyne, with the view of ascertaining, by actual trial, the conditions of working equilibrium and steady motion of shafts and bearings at the very high speeds of rotation that appeared to be essential to the construction of an economical steam turbine of moderate size. Trial shafts were run in bearings of different descriptions up to speeds of 40,000 revolutions per minute; these shafts were 1½ inches in diameter and 2 feet long, the bearings being about ⅝ inch diameter. No difficulty was experienced in attaining this immense speed, provided that the bearings were designed to have a certain small amount of "give" or elasticity, and after the trial of many devices to secure these conditions, it was found that elasticity combined with frictional resistance to transverse motion of the bearing bush gave the best results, and tended to damp out vibrations in the revolving spindle. This result was achieved by a simple arrangement; the bearings in which the shaft revolved was a plain gun-metal bush with a collar at one end and a nut at the other; on this bush were threaded thin washers, each being alternately larger and smaller than its neighbor, the small series fitting the bush and the larger series fitting the hole in the bearing block, these washers occupying the greater part of the length of the bush. Lastly, a wide washer fitted both the bush and block, forming a fulcrum on which the bush rested, while a spiral spring between the washer and the nut on the bush pressed all the washers tightly against their neighbors. It will be seen now that, should the rotating shaft be slightly out of truth (which it is impossible to avoid in practice), the effect is to cause a slight lateral displacement of the bearing bush, which is resisted by the mutual sliding friction of each washer against its neighbor. The shaft itself being slightly elastic, tends to center itself upon the fulcrum washer before mentioned; and under the gyrostatic forces brought into play by the rapid revolutions of the shaft and influenced by the frictional resistance of the washers, the shaft tends to assume a steady state of revolution about its principal axis, or the axis of the mass, without wobbling or vibration. This form of bearing was exclusively used for some years in turbine engines aggregating some thousands of horse-power, but it has since been replaced by a simpler form fulfilling the same functions. In this latter form the gun-metal bush is surrounded by several concentric tubes fitting easily within each other with a very slight lateral play; in the interstices between the tubes the oil enters, and its large viscosity when spread into thin films has the result of producing great frictional resistance to a rapid lateral displacement of the bearing bush; the oil film has also a centering action, and tends, under vibration, to assume a uniformity of thickness around the axis, thus centering the shaft, and, like a cushion, damping out vibrations arising from errors of balance. This form of bearing has been found to be very durable and quite satisfactory under all conditions.

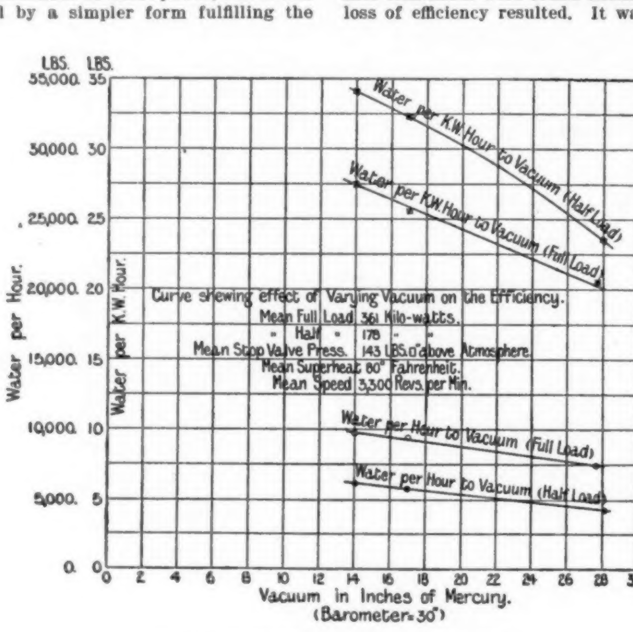


Fig. 3.—PENNSYLVANIA SALT CO.

300 K. W. generator; 250 volts; consumptions at varying vacua at full and half load.

These first turbine engines consisted of two groups of 15 successive turbine wheels, or rows of blades, on one drum or shaft within in a concentric case on the right and left of the steam inlet, the moving blades or vanes being in circumferential rows projecting outwardly from the shaft and nearly touching the case, and the fixed or guide blades being similarly formed and projecting inwardly from the case and nearly touching the shaft. A series of turbine wheels on one shaft were thus constituted, and each one complete in itself is like a parallel-flow water turbine, the steam, after performing its work in each turbine, passing on to the next, and preserving its longitudinal velocity without shock, gradually falling in pressure as it passes through each row of blades, and gradually expanding. Each successive row of blades was slightly larger in passage way than the preceding to allow for the increasing bulk of the elastic steam, and thus its velocity of flow was regulated so as to operate with the greatest degree of efficiency on each turbine of the series. All end pressure from the steam was balanced by the two equal series on each side of the inlet, and the revolving shaft lay on its bearings revolving freely without any impressed force except a steady torque, the aggregate of the multitude of minute forces of the steam on each blade. It constituted an ideal rotary engine, but it had limitations. The comparatively high speed of rotation that was necessary for so small a size of engine as this first example made it difficult to prevent a certain spring or whipping of the shaft, so that considerable clearances were found necessary, and leakage and loss of efficiency resulted. It was, however, perceived that these defects would decrease as the size of the engine was increased, with a corresponding reduction of rotational velocity, and consequently efforts were made toward the construction of engines of larger size, which resulted in 1888 in several turbo alternators of 120 horse-power being supplied for the generation of current in electric lighting stations, and at this period the total horse-power of turbines at work reached in the aggregate about 4,000, all of which were of the parallel-flow type and non-condensing.

About 1890, however, on account of the temporary loss of control of the patents, the radial-flow type of turbine was reluctantly adopted, and this was in 1892 arranged to work condensing, and a 100-kilowatt plant driving a 2,000-volt single-phase alternator at 80 periods, which ran at 4,800 revolutions per minute and therefore was two-pole, when tested by Prof. Ewing was found to take only 27 pounds per kilowatt-hour with 100 pounds steam pressure moderately superheated to about 70 deg. F. and with 27 inches vacuum, a result comparable with the best obtained by reciprocating engines at that time, and thus a wide field was opened up for the use of the steam turbine as a prime mover. Many of these plants, mostly of 150 kilowatts, were made for the electric lighting stations of Newcastle, Cambridge, Scarborough, and elsewhere. In 1894, on the recovery of the original patents, the parallel flow type was reverted to, with considerable improvements in design calculated both to increase the economy and decrease the cost of manufacture. Instead of the steam entering at the center and expanding both ways, one set of blades was replaced by a set of dummy pistons which were substituted for them in which a grooved piston or dummy on the spindle ran close to but not in contact with corresponding grooves in the cylinder, thus making a practically steam-tight

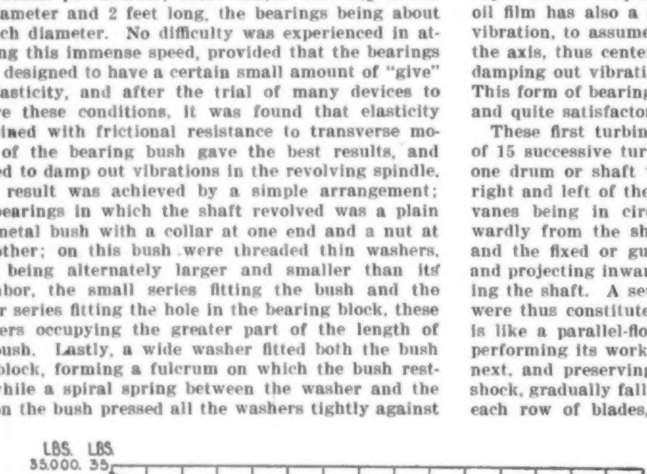


Fig. 1.—HULTON COLLIERY.

300 K. W. three-phase alternator; 420 volts; consumptions at varying vacua.

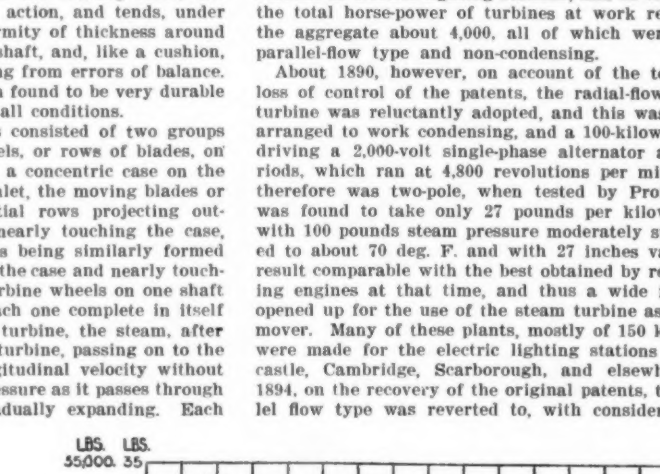


Fig. 2.—METROPOLITAN ELECTRIC SUPPLY CO.

500 K. W. two-phase non-condensing turbo alternator; 1,000 volts; consumptions at varying vacua.

* Read before the Institute of Electrical Engineers.

and yet frictionless joint. The bearings also were made of the later type, with several concentric tubes. At the same time the system of blading was greatly improved, giving a more perfect form of blade, and one also with much greater mechanical strength than in the original formation. The first large turbines of this improved type were of 350 kilowatt output, and were placed in the Manchester Square station of the Metropolitan Electric Supply Company, this station being threatened at the time with an injunction for vibration caused by the reciprocating engines used there, and the substitution of the turbines proved entirely satisfactory to the company.

In 1900, two 1,000-kilowatt turbo alternators were supplied to the city of Elberfeld in Germany, and when tested by a committee of German experts on behalf of the city, the following results, shown in Table I, were obtained:

TABLE I.

Load.	Temperature of steam C°.	Abs. steam pressure. Before Stop Valve 2. Kg. per cm.	Abs. steam pressure. Outlet L.P. Cm. of Hg.	Average load. K.W.	Steam per K.W.-hour. Lbs.	Steam per K.W.-hour. Kgs.	Revs.
Preliminary Test (overload)	230	10·10	4·13	1172·7	18·22	8·26	1493
Normal	192	10·47	3·9	994·8	20·15	9·14	1461
Overload	189·5	10·11	4·65	1190·1	19·43	8·81	1486·6
¾ load	190	10·76	4·0	745·35	22·31	10·12	1469·9
½ load	209·7	10·40	3·4	498·7	25·2	11·42	1473
¼ load	196·4	10·14	3·7	246·5	33·76	15·31	1485
No load with excitation... ...	193	10·34	3·2	—	—	—	1488·3
No load without excitation ...	194·5	10·49	2·68	—	—	—	1504·5

These turbines were of the tandem type, in which the expansion of the steam was first carried out in a high-pressure cylinder and completed in a low-pressure, but it was soon found that better economy, except possibly in very large sizes, could be obtained by having the whole turbine in one cylinder.

TABLE II.

At Stop Valve. Pressure above atmosphere. Lbs. p. sq. in.	At Stop Valve. Superheat. F°.	Vacuum. Inches.	Speed. Revs. per minute.	Load in K.W.	Steam Used per Hour. Pounds.	Steam Used per Hour. Pounds per K.W.
75 k.w. Continuous-Current Turbo for Banbury.						
141·2	84·2	27·1	4,140	75·7	2,006	26·4
144	0	27·0	4,140	75·2	2,201	29·2
142	0	27·1	4,140	56·6	1,777	31·2
135 k.w. Turbo Alternator—Findlay, Durham & Brodie.						
150·8	99·0	27·15	3,600	138·3	3,152	22·8
151·0	81·0	27·3	3,600	66·9	1,845	27·6
200 k.w. Continuous-Current Turbo for Shipley.						
150	57	27	3,000	204·2	4,538	22·23
151	55	27·9	3,000	101·2	2,698	26·67
156	181	27·3	3,000	202·5	4,130	20·39
151	166	28·0	3,000	100·27	2,446	24·41
375 k.w. Turbo Alternator for Dundee.						
152·9	—	27·4	3,000	376·9	8,143	21·6
149·4	148·9	27·5	3,000	374·06	7,202	19·25
350 k.w. Turbo Generator for Pennsylvania Salt Co.						
150	71·3	27·82	3,360	359·5	7,423	20·64
152	65·7	28·27	3,151	185·5	4,346	23·44
140·2	92·3	17·4	3,430	353·5	9,030	25·54
143·4	82·5	17·4	3,255	177·2	5,715	32·26
300 k.w. Turbo Alternator—Hulton Colliery.						
161·0	0	0	3,000	296·6	10,180	34·2
158·0	0	15·33	3,000	297·4	8,732	29·36
157·0	0	19·33	3,000	305·1	8,369	27·43
152·0	0	22·33	3,000	303·4	7,764	25·59
154·0	0	25·33	3,000	303·15	7,336	24·19
158·0	0	26·58	3,000	303·2	7,020	23·15
300 k.w. Turbo Alternator—De Beers Explosives Works.						
150·0	53·3	27·88	3,000	312·1	6·260	20·06
153·0	50·0	27·78	3,000	231·8	4·960	21·45
150·5	40·2	27·9	3,000	154·5	3,670	23·75
1,500 k.w. Turbo Alternator—Newcastle-on-Tyne E. S. Co.						
196	76	27·45	1,200	1,442	25,962	18·0
197	84	27·35	1,200	1,015·5	20,124	19·8
196	76	27·95	1,200	714·0	15,288	21·4
199	77	28·35	1,200	360·5	9,114	25·2
200	68	28·45	1,200	—	2,948	—
After 16 months use the following figures were obtained :—						
203	92	26·11	1,210	1,823	32,431	17·7
207	66	26·46	1,208	1,513	27,582	18·23
1,500 k.w. Turbo Alternator for Sheffield Corporation.						
With Vacuum Augmentor and including 450 lbs. steam per hour used by it. See page 12.						
113·6	108·3	26·69	1,455	1,316·5	24,732	18·76
111·6	156·4	27·12	1,500	1,061·6	19,830	18·66
141	113	27·72	1,500	512·7	11,425	22·3
154	47·5	27·72	1,500	0	3,128	0
Without Vacuum Augmentor						
115·6	143	25·18	1,500	1,029·3	21,264	20·7
137	119	25·97	1,500	534·25	12,820	24·02
150·3	72·4	26·62	1,500	0	2,957·4	0
3,000 k.w. Parsons Turbo Alternator supplied to Frankfort by Messrs. Brown Boveri & Co.						
138·5	235	27	1,350	2,993	44,200	14·74
170·5	187	27·5	1,350	2,518	38,300	15·59
142	120	27·2	1,350	2,600	41,200	15·8
139	114	27·2	1,350	2,600	41,400	15·9
168·5	184	27·9	1,350	1,945	30,800	15·84
146	120	27·6	1,350	2,000	32,600	16·3
137	101	27·4	1,350	1,442	25,400	17·6
142	30	29·3	1,350	0	4,700	excited
142	30	29·3	1,350	0	3,560	non-excited

In all the above tests the barometer is taken as 30 in.
Superheat in degrees Fahr. in all cases.

Large numbers of tests have been made from time to time, chiefly by various consulting engineers and station engineers, out of which are selected those shown in Table II.

In non-condensing turbines the following may be selected:

250 k.w. Continuous Current—Messrs. Guinness, Son & Co.

At Stop Valve. Pressure above atmosphere. Lbs. p. sq. in.	At Stop Valve. Superheat. F°.	Back Pressure. Lbs. p. sq. in.	Speed. Revs. per minute.	Load in K.W.	Steam Used per Hour. Pounds.	Steam Used per Hour. Pounds per K.W.
144	0	0	3,047	251·55	9,510	37·80
142·6	0	6	3,047	255·82	10,584	41·38
138	0	11·1	3,055	253·15	11,194	44·15
143	0	11·0	3,115	125·45	7,475	59·58

500 k.w. Turbo Alternator—Metropolitan E. S. Co.

At Stop Valve. Pressure above atmosphere. Lbs. p. sq. in.	At Stop Valve. Superheat F°.	Vacuum. Inches. Hg.	Speed. Revs. per minute.	Load in K.W.	Steam Used per Hour. Pounds.	Steam Used per Hour. Pounds per K.W.
142	0	0	1,800	506·2	16,903	33·39
147	0	15·67	1,800	509·06	14,800	29·07
144	0	18·57	1,800	514·9	14,591	28·33
145	0	20·67	1,800	512·2	13,945	27·22
146	0	22·57	1,800	509·85	13,714	26·89
154	0	0	1,800	0	3,552	—
151	0	26·1	1,800	0	1,560	—

The effect of varying vacua is shown in a condensing turbine in Fig. 1, which are the consumptions of the 300-kilowatt for Hulton Colliery, and in a non-condensing one in Fig. 3, which are those of one of the Metropolitan Company's 500-kilowatt plants. The effect of varying load is shown in Figs. 4 and 5 for the 1,500-kilowatt plants for the Newcastle Electric Supply Company and the Sheffield Corporation, which latter also shows the advantage gained by the use of the vacuum augmentor, and also for the Frankfort 3,000-kilowatt turbine. In the case of the Newcastle Electric Supply Company's turbine, the consumptions in the latter half of the table were taken after 16 months' use.

It will be seen that under the conditions of, say 140 pounds steam pressure, and 100 deg. F. superheat, and a vacuum of 27 inches (barometer 30 inches) the consumptions are in round numbers as follows: A 100-kilowatt plant takes about 25 pounds of steam per kilowatt-hour at full load, a 200-kilowatt takes 22 pounds, a 500-kilowatt 20 pounds, a 1,000-kilowatt 19 pounds, a 1,500 kilowatt 18 pounds, and a 3,000-kilowatt 16 pounds. These figures are derived from averages of a large number of tests which have been made from time to time. Without superheat the consumptions are about 10 per cent more, and every 10 deg. F. of superheat up to about 150 deg. F. affects the consumption by about 1 per cent.

A good vacuum is of great importance in a turbine, as the expansion can be carried in the turbine right down to the vacuum of the condenser, a function which is practically impossible in the case of a reciprocating engine, on account of the excessive size of the low-pressure cylinder and also of the ports, passages, and valves, which would be required. Thus in a turbine the benefit derived from a good vacuum is much more than in a reciprocating engine, every 1 inch of vacuum between 23 and 28 inches affecting the consumption on an average about 3 per cent in a 100-kilowatt, 4 per cent in a 500-kilowatt, and 5 per cent in a 1,500-kilowatt, the effect being more at high vacua and less at low. It is thus seen how a good vacuum is of importance in a turbine plant, and in this regard it may be well to look into the conditions necessary for obtaining the same. The first point is to avoid all air leaks, and this is easily accomplished in a turbine plant, as there are no packed glands and stuffing boxes to leak. The only places where leakage of air is possible are where the turbine spindle comes out of the cylinder, and here leakage of air is rendered very small by packing the glands with steam, so that any leakage which takes place is steam and not air. The next is

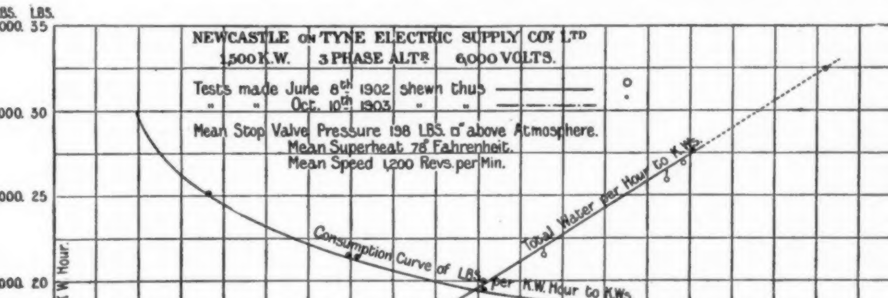


FIG. 4.

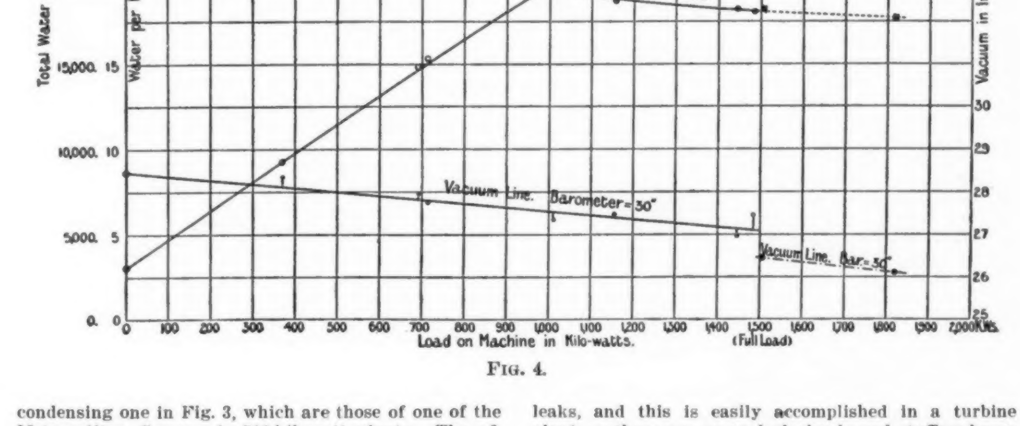


FIG. 5.

to have a suitable condenser, and in this regard sufficient area must be allowed by suitable arrangements of the tubes, and also ample way for the steam between them, proper velocities of the water in the tubes, sufficient supply of cooling water and efficient means of cooling the condensed water so as to keep the air-pump cool and full provision for extracting by the air-pump and other means the inevitable small quantity of air which must leak in. By attention to these requirements it is unnecessary to increase the size of the condenser beyond that used in ordinary practice, so that in the case of the most recent condensers for steam turbines from 10 to 12 pounds steam is condensed per square foot per hour; and at this rate of condensation, vacua of from 27½ inches to 28 inches, with barometer 30 inches, can be obtained at full load. The amount of cooling water generally allowed is about fifty times the full-load steam consumption, which will increase the vacuum under normal conditions by about ¾ inch or 1 inch over that obtained by the usual thirty times the steam used. If we allow 14 feet total head on the circulating pump due to lift, and for friction in the pipes and condensers, etc., which in most cases is excessive, especially where the return pipe is sealed, with fifty times the steam consumption in a plant taking 18 pounds steam per kilowatt-hour, and assuming 50 per cent efficiency in the pump and motor, the power used by the circulating pump is only 1 per cent, and with circulating water thirty times the steam consumption it would be 0.6 per cent, a difference of only 0.4 per cent, such a small difference as not to be comparable with the gain of 4 per cent to 5 per cent in the turbine by the use of increased circulating water.

With regard to extracting the air, a great improvement has been effected by the use of a vacuum augmentor which has been recently introduced. In it the air-pumps are placed about 3 feet below the bottom of the condenser (see Fig. 7). From any convenient part of the condenser, preferably near the bottom, a pipe is led to an auxiliary condenser, generally about 1/20 the cooling surface of the main condenser, and in a contracted portion of this pipe a small steam jet is placed which acts in the same way as a steam exhauster, or the jet in the funnel of a locomotive, and sucks nearly all the residual air and vapor from the condenser and delivers it to the air-pumps. A water seal is provided, as shown in Fig. 7, to prevent the air and vapor returning to the condenser. Thus if there is a vacuum of 27½ inches to 28 inches in the condenser, there may be only about 26 inches in the air-pump, which therefore need only be of small size, the jet compressing the air and vapor from the condenser to about half or a little less of its original volume. The small quantity of steam from this steam jet, which is only about 1½ per cent of that used by the turbine at full load, together with the air extracted, is cooled down and condensed by the auxiliary condenser, which is generally supplied with water in parallel with the main condenser. In this connection it should be observed that condensation in a condenser takes place much more rapidly and effectually if the air is thoroughly extracted than if there is much air present, as the air seems to form a blanket round the tubes and retards the steam getting to them. In Table II. and Fig. 5, are given two curves of a test on a 1,500-kilowatt plant for Sheffield, showing the difference of consumption with and without this augmentor; in these figures are included the steam used by the augmentor, which amounts to 450 pounds per hour. The difference of vacuum is also shown, and when it is remembered that the augmentor jet only took about 1½ per cent of the full-load steam consumption, it is easily seen from the gain of vacuum where the total gain by the use of the augmentor comes in. In this case the vacuum was not as good as it should be, as the cooling water was 85 deg. F., and was only about thirty times the steam consumption at full load.

With reference to the original efficiency of a turbine being maintained, we may refer to the two sets of tests of the Newcastle Electric Supply Company's 1,500 kilowatts after an interval of sixteen months, as shown in Table II. and Fig. 4, when it will be seen that absolutely identical results were obtained in the two tests. Careful examination of the blades of some of the original machines proves that, provided the velocity of the steam is not excessive, as it is not in the Parsons turbine, there is absolutely no cutting action on the blades.

In steam turbines the governing is effected either by a centrifugal governor of a well-known type, which keeps the speed constant, or by a core sucked into a solenoid to keep the voltage constant. In most cases, however, the centrifugal is preferable, especially where there are large changes of load, as in traction work, and it is also preferable where alternators have to run in parallel. In either case the governor moves a small relay plunger which regulates the steam, admitted to a relay, which in turn actuates the main admission valve, generally of the balanced double-beat type. The exhaust from the steam relay is utilized for the steam packing the end glands. Thus the governor having only to move the small plunger has very little work to do, and therefore can be made very sensitive. The sensitiveness is still further increased by keeping the whole governor gear in slight movement by connecting one of the pivots of the levers with a cam. These movements are so rapid as not to affect the even turning moment of the turbine. For parallel running of alternators, an even turning moment is of great importance, and this makes the turbine specially suitable for the driving of alternators. It might be thought that there would be difficulty in making alternators driven by reciprocating engines parallel with turbines, and *vice versa*, but in no case has the running not been satisfactory, and in some—for example, Elberfeld—the turbines have been found to steady the reciprocating engines. In this regard we may quote from a letter from Mr. W. H. Lindley, M.I.C.E., of Frankfort-on-Main, in which he says: "It is surprising to see two plants so entirely different in their speed characteristics parallel with such complete facility—the turbo running on no load and the Sulzer engine loaded, as the case may be, from quarter load to full load. When paralleled, we find the turbo alternators steady the steam engines and thus favorably influence the tension in our lighting supply."

It is important to note that as in these steam turbines there are no rubbing surfaces, there is no need for internal lubrication, and therefore the exhaust is absolutely free from oil. So much is this the case, that in many instances the steam condensed is used as distilled water for delicate chemical work, where the smallest trace of oil would be fatal, and also for heating in breweries and other places. This also enables the condensed steam to be returned direct to the boilers without any oil filters being used.

In the design of dynamos and alternators to be coupled to steam turbines, special regard is to be paid to the large centrifugal force to be encountered. Diameters have to be kept down, and excessive surface speed must also be avoided. Since, then, the diameter has to be small, the length must be increased in proportion and a long core is the result, with moderate diameter, the contrary of slow-speed machines. At the same time, on account of the higher surface speed, the pitch of the poles is greater, thus giving more ampere-turns per pair of poles than is usual. In alternators this gives no trouble at all, as all that has to be provided is sufficiently strong field magnets to overcome the reaction of the armature, and sufficient magnetic resistance to allow of strong field magnets. This extra magnetic resistance can be given either in the air-gap or by saturation of the poles as may be found desirable. These large poles also conduce to diminish magnetic leakage, and as a result very good regulation can be obtained. In low-voltage alternators rotating armatures are preferable, as the iron and copper losses are much less, especially where there are only two or four poles, but rotating armatures, although satisfactory for 500 to 2,000 volts, have not been found suitable for the higher voltages of 6,000 and 10,000 which are now common, and therefore rotating fields and fixed armatures have been adopted in many of the recent alternators. For continuous-current dynamos the same remarks apply, only here sparkless commutation has to be provided for. Carbon brush blocks cannot be used, as at these speeds the brushes are apt to vibrate, and so diminish the intimacy of contact and cause heating and undue wear. The result is that it has been found best to form the brushes of wire, gauze, or foil, preferably of brass, and these must be sufficiently flexible so as to maintain a good contact with the commutator over the whole section of the brush. It follows, therefore, that the properties of the carbon brush blocks in giving sparkless commutation without alteration of the lead of the brushes, cannot in turbine-driven dynamos be utilized, and other means must be adopted to secure sparkless commutation at varying loads. One way is to shift the brushes automatically according to the change of load, and this can be effected by connecting the brush gear to a steam cylinder controlled by a spring and supplied with steam from the point where the steam enters the turbine. At this point the pressure of the steam is proportional to the load of the dynamo, and therefore the piston in the steam cylinder being controlled by a spring takes up a position proportional to the load and thus shifts the brushes to the point of sparkless commutation. Another method is to provide commutating poles as proposed by Prof. Ryan and others, but the best method is to provide compensating winding as proposed by Prof. Forbes, Deri, etc. By these means, with the improvements recently adopted, absolutely sparkless commutation can be secured with fixed brushes, up to, in plants for traction purposes, 100 per cent overload.

The size of turbines is rapidly increasing, many of from 4,000 to 6,000 kilowatts capacity now being in the course of construction, and it is anticipated that still larger plants will be made shortly. Up to the present there are about 600,000 horse-power of turbines of the Parsons type at work and on order in England and on the Continent, in various sizes ranging up to 7,000 kilowatts.

It does not enter into the scope of this paper to describe the many other applications of the steam tur-

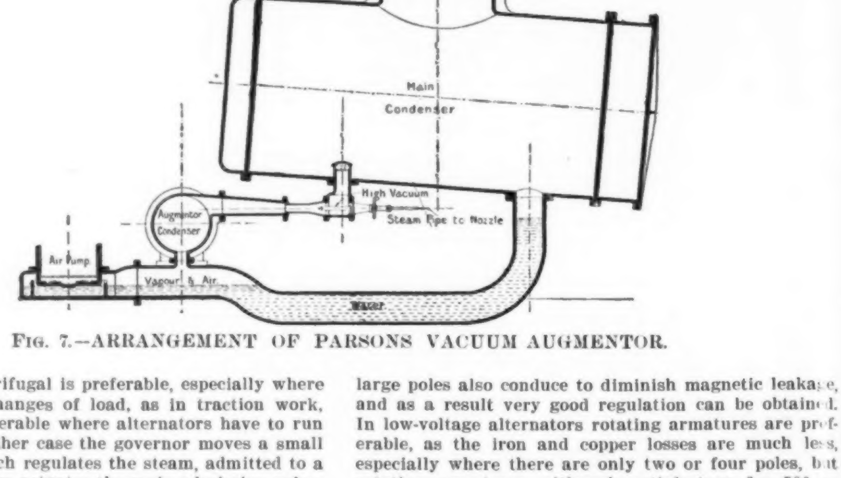


FIG. 7.—ARRANGEMENT OF PARSONS VACUUM AUGMENTOR.

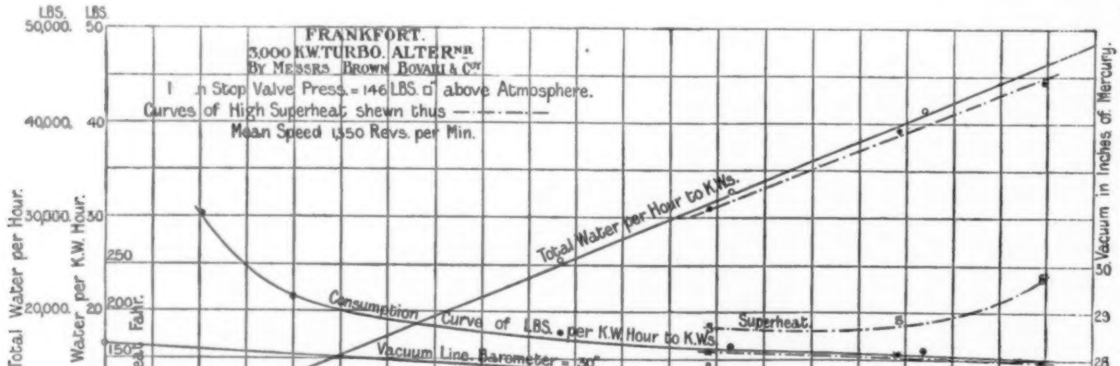


FIG. 6.

bine—to marine propulsion, to the driving of fans, air compressors, blast-furnace blowers, etc., or to lifting water to great heights by the use of high-speed centrifugal pumps, but it seems now certain that for many purposes, especially in large sizes, the steam turbine has become a most formidable competitor to the best reciprocating steam engines.

THE MERCURY ARC.*

By E. WEINTRAUB, PH.D.

THIS paper contains results of an investigation on the properties and nature of the conductivity of metallic vapors carried out in the research laboratory of the General Electric Company. The investigation was started with the practical purpose in view of using the arc discharge in metallic vapors, and especially mercury vapors, as a source of light. The subject is of special interest to the electrochemist, whose science can be in the main properly defined as the science of conductivity of a particular kind of matter, namely, of solutions and molten salts. The ionic theory of conductivity that had its birth in electrochemistry found afterward fruitful applications in the theories of conductivity in gases. Any increase of our knowledge in this last-named branch is in its turn apt to react on the general structure of that theory, and eventually influence the electrochemical ideas themselves.

The Rôle of the Cathode in the Starting Process.—The distinctive feature of the conductivity of gases and metallic vapors, in contradistinction to that of metals and electrolytes, consists in that under ordinary conditions, in absence of exterior ionizing agents, the current itself has to create the material which is to carry it from one electrode to the other. As this material does not exist at the beginning, some special means must be used to start the discharge, and thus we meet in gases and vapors with the problem of starting, a problem unknown in the realm of conduction through metals and electrolytes.

The new way of starting an arc discharge in mercury vapor that I want to expound here was the outcome of the theoretical conceptions on the mechanism of the arc and the function of the ionization at the

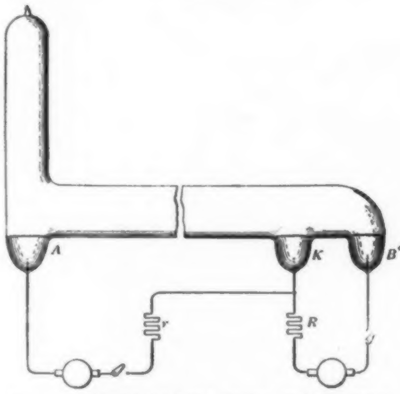
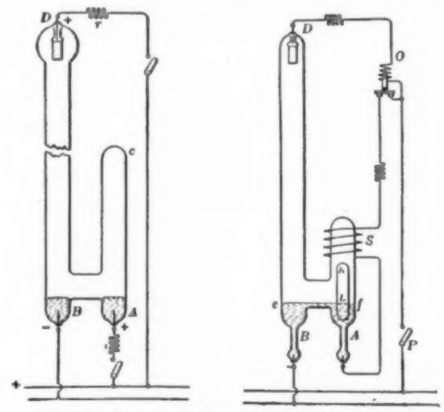


FIG. 1.—APPARATUS FOR STARTING MERCURY-VAPOR ARC.

cathode surface that I formed in the course of these investigations. According to these conceptions an arc discharge in metallic vapors is a discharge deriving its carriers, at least in the immediate neighborhood of the cathode, from the material of that cathode. The application of a moderate electromotive force is of itself insufficient to start the process by which these carriers are formed out of the material of the cathode. The new fact discovered was that this formation of carriers (the "ionization" process) is started and the arc discharge made possible if a spark or a small arc is produced at the surface of the cathode. The following experiment will serve to illustrate this statement:

The tube is represented in Fig. 1. *K* is a cup filled with mercury. *A* and *B* are electrodes of graphite, iron or mercury. In the figure they are shown as mercury cups. The tube is exhausted on the Sprengel pump to the highest possible vacuum, and by some means, such as heating from outside, or by the arc itself, the gases are driven off from the walls of the tube and the anode material. Two different sources of direct current are used—one applied to *K* and *B*, the other to *K* and *A*, in such a way that *K* is the negative pole of both. If, now, the little arc *BK* is started by bringing the electrodes into contact and separating them, the other arc, *KA*, starts instantaneously. If the connections are changed in such a way that *K* is the common positive pole of the two sources, the arc *BK* does not cause the starting of the arc *AK*. The fundamental importance of the cathode in the process of starting an arc is illustrated by this experiment in a simple and striking way. We can dispense in the tube of Fig. 1 with the use of two different sources and use the same source with different resistances in the two branches. In Fig. 2 *B* is the cathode, *D* and *A* are both connected to the positive pole; r_1 is a large resistance; *r* is a small resistance used for the purpose of regulating the current in the main arc, *BD*. By slightly shaking the tube the arc, *BA*, starts, whereupon the arc, *BD*, starts of itself. The switch, *S*, in the side branch arc, *BA*, can then be opened and the auxiliary arc discontinued.

For the practical use of this starting method the operations of separating the electrodes, *B* and *A*, and discontinuing the auxiliary arc the moment the main arc is started must be performed automatically by the current itself. One of the arrangements that I have devised is represented in Fig. 3. *KL* is an iron plunger, *S* a solenoid, and *O* a magnetic cut-out. The solenoid, *S*, in pulling up the plunger, *KL*, produces the auxiliary arc. The current in the main arc flows through the



FIGS. 2 AND 3.—TYPES OF STARTING APPARATUS USING SINGLE SOURCE.

magnetic cut-out and automatically opens the circuit of the auxiliary arc.

It is interesting to remark that the old method of starting an arc by contact is based also on excitation of the cathode; only, instead of having one arc instantaneously formed by another, we have a continuous growth, a short arc producing a longer one.

Influence of the Conditions Prevailing in the Space Between the Electrodes on the Starting Process.—The space separating the electrodes has an important influence on the velocity with which the starting takes place, but this influence is mainly of a negative character. The space must present as little hindrance as possible to the flow of ions starting from the cathode surface. Accordingly, the degree of vacuum must be the highest obtainable, and the more careful the exhaustion the more instantaneous is the starting. If foreign gases, or inert ordinary mercury vapor, are present, the starting is slow. The ionized vapor is seen to rise from the surface of the cathode and slowly move along the tube, impeded in its rise not only by the gases present in the tube, but also by the mercury vapor which volatilizes from the heated surface of the mercury cathode. When the vapor reaches the anode the arc will eventually start, but if the pressure of the foreign gases is high enough the arc does not establish itself at all.

Function of the Anode in the Starting Process.—In contradistinction to the cathode the anode plays no rôle whatever in the starting process. It receives the carriers of the current without any previous excitation.

The Influence on Stability of the Arc Conditions at the Cathode Surface.—In the study of the conditions of the stability of the mercury arc one meets with a phenomenon which is being observed in all arcs, i. e., the existence at each impressed voltage of a lower limit of current, below which the arc is not stable and extinguishes. The experiments performed on the mercury arc led me to the conclusion that the physical cause of it is in the conditions prevailing at the very surface of the cathode. Under ordinary circumstances

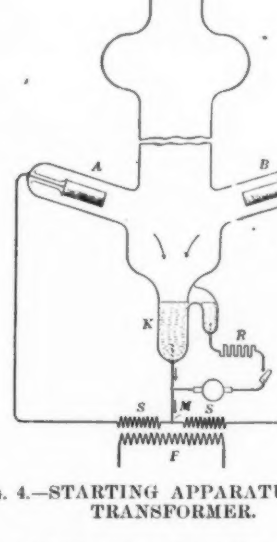


FIG. 4.—STARTING APPARATUS USING TRANSFORMER.

there is a bright spot on the surface of the mercury cathode, which spot is continually wandering about on that surface. The wandering of this spot has not found as yet any very satisfactory explanation. This spot is, according to the conceptions expounded here, the place where the production of ions takes place, and the continuous motion of that spot means a disturbance of the ionization process and a danger to the existence of the arc. The wandering of the spot can be avoided in two different ways—either by making the surface of the cathode small, of the same magnitude as that of the spot, or by having a wire of iron or platinum project above the surface of the mercury.

The conductivity of the arc depends on the relative amounts of ionized and inert mercury vapor. If a sufficient condensing space is provided so that the pressure of the ordinary mercury vapor volatilized from the cathode is kept down to a certain value the conductivity of the arc is almost exactly proportional to the current.

The Alternating-Current Arc in Metallic Vapors.—We have seen that the ionization process at the cathode must be initiated if an arc discharge in metallic vapors is to be established and that this ionizaton process must be kept up by the supply of a certain amount of energy if the arc is to maintain itself. It is in these facts that lies the explanation of the difficulty that previous investigators have found in maintaining an alternating-current arc between metallic vapors. With every change of polarity the ionization process at the cathode dies out and moderate electromotive forces are insufficient to start that process by themselves on the surface of the other electrode when the latter becomes of negative sign. It is therefore obvious that if an alternating electromotive force of moderate value is to maintain an arc in metallic vapors, one metallic electrode must permanently keep its negative sign, notwithstanding the perpetual change of polarity. This, if realized, would mean a unidirectional flow of current in the arc, and consequently rectification of the alternating current.

If, referring to Fig. 1, the electrodes, *K* and *B*, are connected to a source of direct current, *K*, being the cathode, and a source of alternating electromotive force of a few hundred volts is applied to *K* and *A*, that

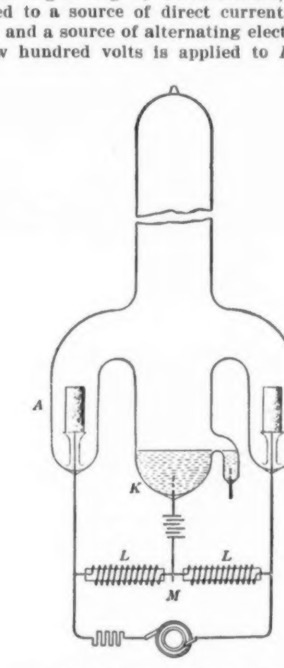


FIG. 5.—STARTING APPARATUS USING GRAPHITE ELECTRODES.

half of the alternating current which has the direction *AK* (*K* cathode), passes, since the ionization process at the surface, *K*, is kept up by the direct-current arc; the opposite half wave is completely suppressed. The arrangements by means of which both halves of the current wave are made to pass in the arc and are superimposed in the same wire are mainly applications of electrical principles to the given case. Of all the devices used by me I mention but two. In both of them the tube contains three electrodes, one of mercury, the others of graphite, iron, or mercury. The one electrode of mercury serves as the cathode, the two others, which we will suppose to be made of graphite, serve as anodes of the rectified arcs. In the first arrangement, represented in Fig. 4, a transformer is used, the ends of the secondary of which are connected to the two graphite anodes. A wire taken out from the middle of the secondary is connected to the cathode. One half wave takes them in the arc in the direction *AK*, the other in the direction *BK*, and both are superposed in the same direction in the neutral wire of the transformer. The current derived is pulsating, and if the rectified voltage or current is low, usually a small direct-current arc, springing from the same cathode, is necessary to keep the cathode alive during the zero point of the current. If a constant-current transformer is used this direct-current arc can be dispensed with.

In the second method the alternating voltage is directly applied to the two graphite electrodes and two reactance coils are connected in the way shown in Fig. 5.

On the Mechanism of the Ionization Process at the Cathode.—An attempt was made to get quantitative data by using mercury arcs with cathodes made of less volatile material than mercury. If a piece of graphite or any other conducting material that does not combine with mercury, and a mercury cup, both inclosed in an exhausted tube, are connected respectively to the negative and positive pole of a source of an electromotive force, the electrodes brought into electrical contact and separated, an arc is formed with the solid

* Abstract of a paper read at the general meeting of the American Electrochemical Society, Boston, Mass., April 25, 1905.

electrode as cathode. The behavior of these solid cathodes is the same as that of the mercury cathode. A bright spot is wandering on the surface of the solid piece and wherever that spot strikes the cathode, disintegration of its material takes place. This disintegration is characteristic of the cathode of a metallic arc in an exhausted space. If a piece of charcoal is used as a cathode the motion of the cathode

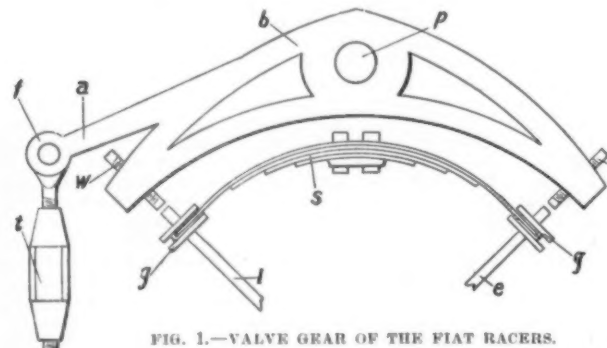


FIG. 1.—VALVE GEAR OF THE FIAT RACERS.

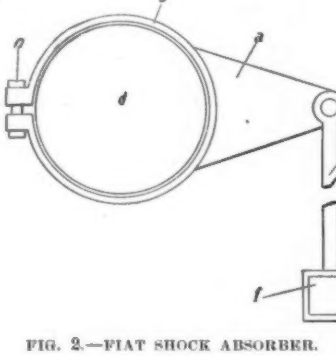


FIG. 2.—FIAT SHOCK ABSORBER.

spot leaves fine lines and grooves burned, so to say, into the material. The loss of weight of these solid cathodes is usually very small. The largest part of it is, however, due to the mechanical disintegration of the material which accompanies the electrical one, which circumstance deprives the result of theoretical significance. We can, therefore, conclude from these experiments that a transfer of matter either does not take place at all, or is so small as to be of the order of magnitude that would be required

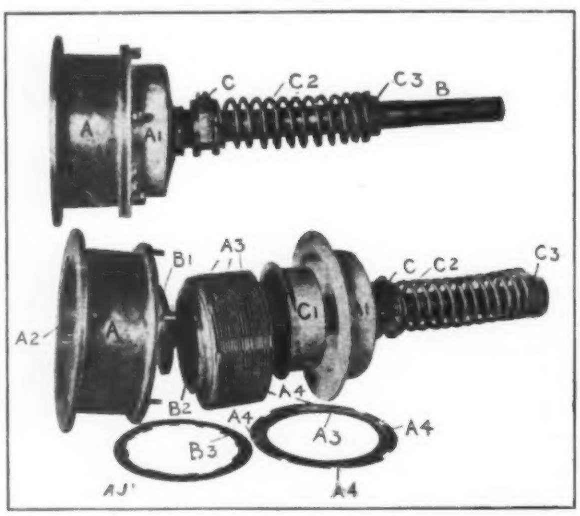


FIG. 3.—THE FIAT DISK-CLUTCH, COMPLETE AND IN PARTS.

In the lower illustration, two of the disks (driven, B^3, and driving, A^3) are shown separately, and the separating springs, A^4—which are notched out of the periphery of the latter—are clearly visible.

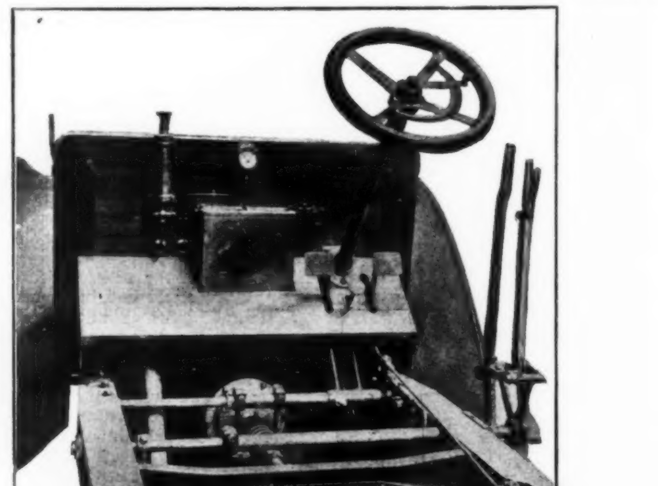


FIG 4.—VIEW OF THE 1905 MODEL FIAT CHASSIS, SHOWING DASH, CLUTCH, CONTROLLING LEVERS AND PEDALS.

by the value of the electronic mass accepted in the modern theories.

The second question of special interest in connection with the theory of the arc refers to the cause of the ionization process at the cathode. The formation of current-bearing particles does not in all probability take place at all in the arc itself. The potential drop in the arc and that at the cathode surface (about five volts) are so small that productions of ions by collision seems to be excluded. As the anode plays no appreciable role during the starting and the running of the arc, we are led to the conclusion that in an arc through metallic vapors in an exhausted space the cathode is the only place where the current-bearing material is formed.

THE WINNING AUTOMOBILES IN THE SIXTH INTERNATIONAL CUP RACE FOR THE BENNETT TROPHY.

II. The Italian Fiat Cars.

The Italian cars were undoubtedly the speediest machines in the race this year, and they were driven very skillfully by Lancia, Cagno, and Nazzari. The first-mentioned of these chauffeurs made the fastest time of any one, covering the 85.3-mile circuit in 1 hour, 34 minutes, and 57 seconds, or at the rate of 54.3 miles an hour, whereas, the average speed of the winner, Théry, was but 48.5 miles an hour, and his first and fastest circuit of the course required 6 minutes and 10 seconds longer than Lancia's. The latter's machine dropped out on the third round owing to a stone flying up and breaking the radiator, thus allowing the water to leak out. The other two Fiat cars, however, finished the race, making the four circuits of the course (341.2 miles in 7 hours, 19 minutes, 9 seconds, and 7 hours, 21 minutes, 22 seconds, respectively, thus gaining second and third places by the maintainance of average speeds of 46.6 and 46.5 miles an hour. A second Richard-Brazier car, driven by Callois, obtained fourth place, with an average speed of 45.8 miles an hour, while fifth position was taken by Werner with a German Mercedes car, which made an average speed of 42.5 miles an hour.

The Fiat racers differ somewhat in the details from the standard touring car, as produced this year. In their general plan, however, they are identical. All three of the racers have 4-cylinder engines of 180 millimeters (7.086 inches) bore and 150 millimeters (5.905 inches) stroke, and the rated horse-power is 110. The make-and-break igniters are supplied with current from a gear-driven Simms-Bosch magneto. Compression relief cams raise the exhaust valves slightly and relieve compression in starting the motor. The carbureter is fitted with a piston valve which uncovers auxiliary air ports when opened to the full extent. For the convenience of the driver there are two accelerator pedals (one for either foot), so that he can accelerate or throttle the motor with either foot, and at the same time use the other foot to operate the clutch.

The chassis is of pressed steel, as usual. The wheels are $34\frac{1}{4}$ inches in diameter, fitted with $3\frac{1}{2}$-inch tires, in front; and $34\frac{3}{4}$, fitted with $4\frac{3}{4}$-inch tires in the rear. The wheel base is 110 inches and the tread 54 inches. The Italian cars were a little shorter and less powerful than the Mercedes, and despite the fact that they were geared lower than these, they made much faster time.

The most notable feature in the 1905 Fiat racers is the cylinder-head construction. The heads are cast integral with the cylinders, which, in turn, are cast in pairs; the combustion chambers are almost spherical in shape and have no pockets of any kind. There are simply two openings, one on each side of the cylinder, into which the valve castings are fitted in such a way that each cylinder carries its two valves inclined at an angle of forty-five degrees from the vertical, closing downward and placed one on each side.

In the sketch Fig. 1, *l* and *e* are the valve stems. Each stem carries a grooved collar, *g*, which is screwed and locked on, while the valve head is contained in a spherical casting which at the same time forms the valve seat and the pipe connection. The casting is attached to the cylinder by means of studs and the joint is made tight by a suitable gasket. In the grooves of the collars, *g*, are fitted the forked ends of the four-leaf flat spring, *s*, which in form closely resembles the usual carriage spring. This spring is secured to a bracket on the top of the cylinder head, and serves to keep the valves seated. A light but stiff beam, *b*, of forged steel is fulcrumed at *p*, an extension of the bracket being provided for this purpose. In the ends of the beams are screws, *W*, which are used to adjust the amount of play allowed the beam before the valves commence to move when the beam oscillates.

To produce the necessary oscillation of the beam an eye, *f*, is formed at one end, to which is connected the rod, *r*, whose length is adjusted by means of the turnbuckle, *t*. At the lower end of the rod is a stirrup moving in a suitable guide, and this stirrup is acted upon by a cam on the single cam-shaft, so that it is given a downward pull and an upward push alternately, opening the inlet valve and the exhaust valve successively, the flat spring causing the valves to return to their seats.

The regulation of the speed of the engine is effected by sliding the countershaft longitudinally about $1\frac{1}{2}$ inches, bringing a different profile of the cam under the stirrup and thus altering the lift of the valves.

A notable feature of the machine is also the clever way in which the designer got around the shock absorber patent. A cast-iron drum, *d*, Fig. 2, about 4 inches in diameter is bolted direct to each of the side members of the frame a few inches in front of the axle; but of course above it. A steel band, *b*, lined with leather, encircles each drum, the tension of the band being adjustable by means of the bolt and locked nut, *n*. An arm, *a*, secured to the band is connected to the axle at *f*, by means of the rod, *r*, and suitable fittings. The object of this arrangement is of course to introduce a resistance to the violent play of the springs and thus prevent dangerous jumping of the machine, which is avoided by the Truffault suspension fitted to the French and American cars and to the English Napier.

Less important from a technical point of view, but still quite interesting, is the fact that the Fiat drivers dispensed entirely with the usual type of spring clips,

CAGNO ON HIS 120-HORSE-POWER FIAT RACER WHICH GAINED SECOND PLACE IN 7 HOURS, 19 MINUTES AND 20 SECONDS, OR AT AN AVERAGE SPEED OF 46.6 MILES AN HOUR.

THE ITALIAN AUTOMOBILES WHICH GAINED THE SECOND AND THIRD PLACES IN THE SIXTH INTERNATIONAL RACE FOR THE BENNETT TROPHY.

simply winding around the entire length of each spring a single thickness of fine but very strong whipcord. This is by no means a new expedient, being frequently adopted by racers and tourists.

Regarding the regular touring car of this make, two of the standard models are nominally the same power as those of last year, viz., 16 horse-power and 24 horse-power, but the engines are now of larger size, and their actual output is nearer 25 horse-power and 40 horse-power respectively. The stroke of the cylinders has, for this purpose, been lengthened in the smaller model to 125 millimeters, and in the larger model to 150 millimeters, this being an increase of 15 millimeters in the one case and 25 millimeters in the other. The bore, however, remains the same as previously, being 110 millimeters and 125 millimeters respectively. The other standard car, which is a new model this year, has a 60 horse-power engine.

Previously the pistons had dome-shaped tops, but this shape has now been abandoned in favor of the flat-ended type. Instead of screw fittings above the valves, the new engines have their inspection-covers held down by yokes, which facilitate their removal, and half compression cocks are now fitted into the cylinder heads. So far as the arrangement of the valves is concerned, the engines of the standard Fiat touring cars are identical with those of last year, while the igniters, and also the method of "timing," remain unaltered. The "timing" on the Fiat engines is automatic, being entirely controlled by a mechanical governor, which operates a rod fitted inside the hollow inlet-valve cam-shaft. This rod alters the position of the igniter cams relatively to the cam-shaft, and, since the gear-wheel driving the magneto is also mounted on this rod the magneto is, therefore, kept in synchronism with the tappets.

A slight modification has been made in the throttle-valve, which is now horizontal, but the valve itself is still inter-connected with an auxiliary air-valve, and the engine is also under the control of a centrifugal governor which is connected with it by a rod that passes through the hollow exhaust-valve cam-shaft. The large centrifugal circulating pump is mounted on the side of the crank-chamber, and the water-pipes still retain the same directness and absence of sharp bends. The belt-driven lubricator on the dashboard, which feeds oil in measured doses down each oil pipe, is also retained in a somewhat modified form.

The most important change is in the clutch, which is now of the multiple-disk type—that formerly fitted being of the internal expanding variety. The component parts of the clutch are very clearly shown in Fig. 3, and the clutch complete is also visible, in place on the chassis, in Fig. 4. It is exceedingly compact, and is inclosed in a cylindrical case, *A*, which is bolted to the boss of the large fly-wheel, an aluminium cover, A^1, being provided to retain oil and exclude dust. The driving disks fit freely on longitudinal keys which project from the inner face of the member, *A*, and the driven disks also fit freely on longitudinal key-ways which are cut in the outer surface of a member, B^2—secured by the flange, B^1, to the driven shaft, *B*.

When in place, the driving disks and the driven disks are arranged alternately, and overlap one another, but they are normally prevented from "seizing" when the clutch is disengaged by the action of small leaf springs, A^2, which separate them. These leaf springs are formed by notching the outer edge of the driving disks at four places on the circumference, and then bending back the small pieces which have been partially cut away. The positions of some of these springy separating pieces are clearly indicated in Fig. 3. The clutch is engaged by allowing the clutch-spring, C^2, to compress all the disks firmly together. The force of the clutch-spring operates through a cup-shaped member, C^1, which has a suitable diameter for operating upon the disks, and the clutch is disengaged in the usual way by a foot pedal, which is connected with the clutch-fork *C*. A simple adjustment for the clutch-spring is provided by means of the nuts, C^3.

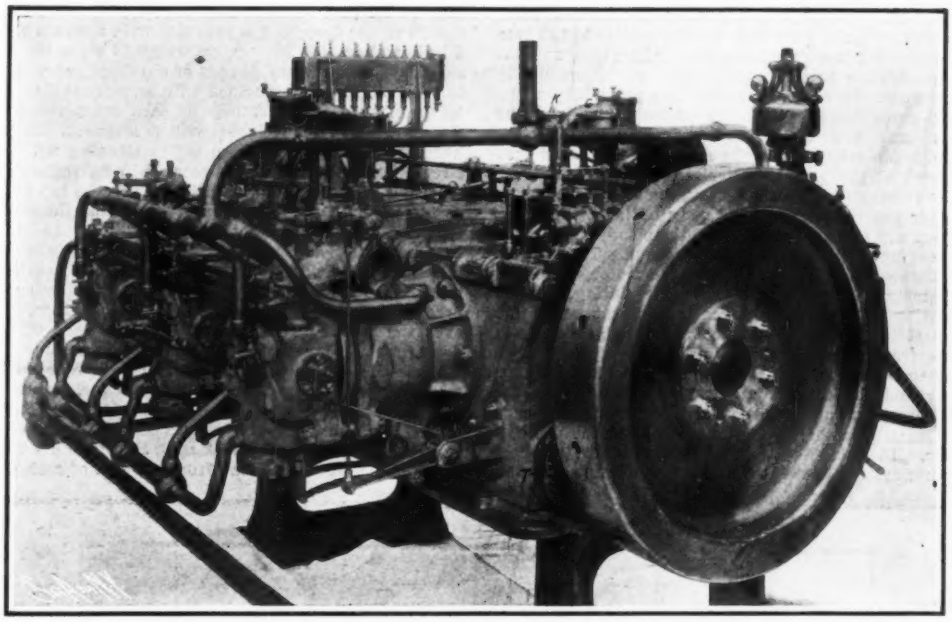
The other parts of the chassis have not undergone radical change, but the gear-box no longer has a three-point suspension. The shape of the gear-box is, moreover, somewhat modified, and the differential case, which is still in one piece with the main casting, is self-contained. The change-speed gear is similar to that of last year, and is modeled on the Mercedes pattern. Another resemblance to the Mercedes vehicle is to be found this year—the presence of a foot-brake on the second-motion shaft, in addition to that on the countershaft. These two brakes are interconnnected through a compensating device with the same foot-pedal, and both have water-cooled drums.

The countershaft brake is of the simple band variety, and is actuated by a toggle mechanism; the second-motion-shaft brake is similar in principle, but is operated by an ingenious arrangement of cams. The hub-brakes are—as before—of the internal expanding type, and are supported, as formerly, on the large flat radius-rods which the Fiat Company were among the first to introduce into their vehicles, and which have now become so very popular with many well-known makers. Notwithstanding the popularity of the Fiat cars in the past, the alterations which we have enumerated as having been embodied in this year's models cannot but insure an increased circle of users in the future, while the magnificent running of the competing cars in the Gordon-Bennett race must in itself very greatly strengthen the confidence with which these vehicles have always been regarded in the automobile world.

For the above particulars of the Fiat cars we are indebted to the Automobile and the Automotor Journal.

HIGH-POWER ENGLISH GASOLINE MOTORS FOR DRIVING AMERICAN LOCOMOTIVES.

A SERIES of experiments are to be carried out by the General Electric Company, of Schenectady, with the gasoline-electric system of propulsion for locomotives. In Great Britain this system has been in vogue for some months on the North-Eastern Railroad with conspicuous success. Two types of English gasoline motors for the General Electric Company are being constructed in Great Britain, one by the Maudslay Motor Company, of Coventry, and the other by the Wolseley Motor Company, of Birmingham, both of which firms have had considerable experience in the application of gasoline motors to railroad traffic.



THE MOTOR VIEWED FROM THE FLYWHEEL END.

B. Flywheel. D, E, F. Water jacket inlets to cylinders. G, K. Gasoline and kerosene float-feed chambers. M. Magneto. N. Make-and-break igniter. O. Oiler. T. Chain gear wheel for driving pump. V. Governor. W. Main water jacket outlet.

The Maudslay motor is of their standard vertical type. There are six cylinders, each having a stroke and bore of nine inches, and developing 200 horse-power at 600 revolutions per minute. Both the inlet and exhaust valves are placed, for accessibility, on the top of the cylinder heads, immediately above the pistons, and are made interchangeable. The valves are operated through skew gearing and a vertical shaft, on which the governor is mounted, and which is connected with a second set of skew gears to the Maudslay patent hinged lay-shaft. The feature of the latter is that when thrown over immediate access is given to all the valves. The governor works on a throttle valve, in the inlet pipe, and governs the volume of gas supplied to the engine.

The crank is of special design, the feature of which is the provision of side inspection doors. By this arrangement the pistons and connecting rods, or the crankshaft brasses, may be adjusted, or, if it is so desired, the pistons and connecting rods may be removed bodily without disturbing the main joints of the engine. The crankshaft is forged out of the solid, and turned bright all over. Heavy bearings are provided between each cylinder.

The lubrication is of the forced type throughout. There is a rotary pump driven direct from the crankshaft by gears, and the oil is forced to all parts through the center of the hollow crankshaft. Adequate lubrication is thus supplied to all the various bearings.

The water circulation through the cylinder jackets is also effected by means of a rotary pump, driven from the crankshaft, by the same gears as those that drive the oil pump. The ignition is of the high tension type with accumulators and coil. An efficient muffler is fitted so that the noise of the exhaust gases is reduced as much as possible.

Owing to the heavy compression, the motor is started by means of a small, single-cylinder, 8-horse-power motor, which is shown in position in our illustration. When the latter is well under way, its motion is transmitted to the larger engine through a special clutch fitted with a free wheel. When the main engine is set in motion it over-runs the auxiliary motor without driving it. This is an entirely new method of starting a large gasoline motor.

This six-cylinder engine is designed to generate 200 horse-power at 600 revolutions per minute. This was the power contracted for. The preliminary tests demonstrated the fact, however, that there was a large margin of power at the disposal of the engineers, for 300 horse-power was developed at a somewhat higher number of revolutions. The Wolseley 140-horse-power engine is of the triple opposed-cylinder type. It, too, has a bore and stroke of 9 inches, and is adapted to be run on either gasoline or kerosene.

SIDE VIEW OF THE TRIPLE OPPOSED-CYLINDER MOTOR.

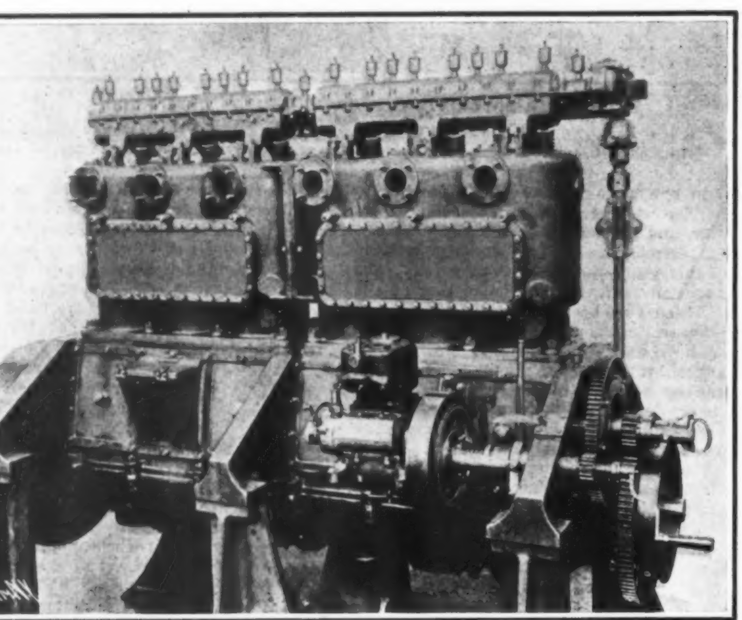
C. Incased cam shaft driving gears. D, E, F. Water jacket inlets to cylinders. G, K. Gasoline and kerosene float-feed chambers. O. Oiler. P. Gear water pump. S Revolution indicator. V. Governor. W. Water outlet.

A 140-HORSE-POWER WOLSELEY SIX-CYLINDER HORIZONTAL KEROSENE ENGINE FOR AN EXPERIMENTAL LOCOMOTIVE BEING BUILT BY THE GENERAL ELECTRIC CO.

Two vaporizers are fitted to the engine, one serving each row of three cylinders. The vaporizers are of the patent Wolseley type especially designed to be used with kerosene, though they are made to operate with gasoline as well. Each vaporizer is provided with two float-feed chambers, one for use with kerosene, and the other with gasoline, according to which fuel is being used. If desired, however, they can be utilized alternately, as the vaporizers are equipped with two-way cocks. By this arrangement the motor can be started on gasoline, and, when the engine has become sufficiently warm, the kerosene supply can be turned on in lieu of the gasoline. When kerosene is being used, the exhaust gases from the cylinder are deflected into jackets round the vaporizers and inlet pipes, so that the gasification of the heavier fuel can be completely carried out. In order to obviate any possibility of exhaust gases leaking past the piston rings into the crank case and then passing to the engine-room through the relief valve, the air from the crank case is drawn off through the vaporizer.

The two lay shafts for operating the valves are driven by spur gearing, the wheels being of large diameter, and heavily made so as to assist the steady running of the engine and give an even torque. The wheels are shown incased at the end of the motor, in one of our illustrations. The gear water circulating pump is driven by a chain from the gear wheel seen beside the flywheel in one photo. Make-and-break ignition with gear-driven magneto is used.

In the majority of engines of such large horsepower and the consequent heavy compression in the cylinders, starting is generally facilitated by means of a small auxiliary single-cylinder motor of 8 horsepower. In this Wolseley engine, however, a novel starting system is adopted. When the motor stops an



200-HORSE-POWER SIX-CYLINDER MAUDSLEY GASOLINE ENGINE FOR A GASOLINE-ELECTRIC LOCOMOTIVE.

Note the small single-cylinder motor used for starting the large engine.

indicator shows the position of the various pistons. The three cylinders that would ordinarily fire the earliest are ascertained, and the charges within them are ignited by means of cordite cartridges. This operation is carried out as follows: The flanged covers carrying the high tension electric ignition plugs of the three selected cylinders are removed, and a special type of flange cover which contains the cordite cartridge mechanism is substituted. The cordite charge fitted to the cylinder which is nearest the normal firing point is exploded by hand. This explosion sets the crankshaft in motion and the cordite cartridge fitted to the remaining two cylinders are ignited at their appointed moment by the trip rods of the low tension magneto gear. Consequently these cartridges are automatically exploded at the correct moment. The firing of these three cartridge-charged cylinders supplies sufficient impulse to the crankshaft to enable it to be kept rotating by the other three cylinders which still retain the electric ignition gearing, and these are sufficient to keep the motor running slowly, with the compression of the first three cylinders relieved by raising the exhaust valve. The cordite cartridge flange covers are then removed, and the electric ignition covers reinstated, the ignition connected up at leisure, the exhaust valves released, and the whole of the six cylinders are then brought into action. Of course, in the case of momentary or short stoppages of the engine, re-starting can invariably be accomplished by simply switching on the current.

The trials that were carried out with this motor in the testing shop prior to its shipment to this country were eminently satisfactory, when running both on gasoline and kerosene. Curiously enough the consumption with each type of fuel was precisely the same, being 0.65 pint per brake-horse-power per hour.

[Continued from Supplement No. 1544, page 24739.]

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES.*

By Charles E. Munroe, Ph.D.

In the MacArthur-Forrest process, the cyanide solution containing gold and silver is next run into zinc boxes for the precipitation of the precious metals. The zinc boxes, like the leaching vats, vary in character at the different works. A form in common use in the United States is made of 2-inch dressed plank, bolted together and painted with paraffin paint; it is divided into six compartments, 13 by 20 inches in cross section and 20 inches deep, and is provided with a screen about 4 inches above the bottom, on which to place the zinc shavings. About sixty pounds of shavings are required to fill the box. It is provided with an inlet and an outlet pipe, and in the bottom of each compartment is placed a 1-inch pipe closed with a stopcock, through which the slimes are drawn off in cleaning up. The circulation in the zinc box is secured by having the first partition of a compartment extend from the top of the box to within 3 inches of the bottom, while the second partition extends from the bottom of the box to within 2 inches of the top. The screen for the zinc shavings is stretched between. The solution from the entrance pipe falls to the bottom of the box, passes under the first partition, rises up through the zinc shavings, flows over the second partition, and thus proceeds up and down from compartment to compartment until it reaches the exit pipe of the box. The Mercur mill is equipped with long sheet-iron boxes having wooden partitions wedged into place; these can easily be removed for cleaning up, the slimes being all brushed together. At the Cripple Creek mill, the slime discharge pipes of the zinc boxes lead from the side of each compartment and discharge the slime into a trough leading to a tank.

When the potassium cyanide solution comes into contact with the gold in the leaching vat, the gold is dissolved, forming potassium aurocyanide, according to the following equation:

$$4\,KCy + 2\,Au + O + H_2O = 2\,KAuCy_2 + 2\,KHO.$$

According to Christy,† when the solution of potassium aurocyanide, containing, as it usually does, an excess of potassium cyanide, is brought into contact with the zinc, the reaction may be represented by

$$2\,KAuCy_2 + 3\,Zn + 4\,KCy + 2\,H_2O = 2\,(ZnCy_2 . 2\,KCy) + K_2O_2Zn + 2\,H_2 + 2\,Au;$$

but in the absence of free potassium cyanide the successive reactions taking place may be summed up in the following equation:

$$4\,KAuCy_2 + 4\,Zn + 2\,H_2O = 2\,ZnCy_2 + ZnCy_2 . 2\,KCy + K_2O_2Zn + 2\,H_2 + 4\,Au.$$

Christy also says:

"According to the substitution reaction, one atom of zinc replaces two atoms of gold, or one ounce of zinc should precipitate 6.2 ounces of gold; whereas, as everyone knows, in practice one ounce of zinc will precipitate only one-fifth to one-fifteenth of an ounce of gold, or thirty to ninety times less than the amount called for by the reaction by substitution. According to the reactions I have suggested, in the absence of free cyanide of potassium and caustic potash one ounce of zinc should precipitate 3.1 ounces of gold; in the presence of a moderate excess of cyanide of potassium it should precipitate 2.06 ounces. The apparent discrepancy that seems still to remain between theory and practice is in reality due to the facts, first, that the free alkali (potash in particular) formed in the solution of the gold, or added to neutralize the free acid in the ore, also dissolves the zinc as potassium zincate; second, that an excess of potassium cyanide dissolves the zinc on its own account, both as the double cyanide and as the zincate of potassium; third, it should also be remembered that water containing dissolved oxygen attacks metallic zinc quite vigorously, forming hydrate of zinc."

According to Packard, the 60 pounds of zinc shavings required to fill the zinc boxes described above will precipitate the gold from about 1,500 pounds of 0.2 per cent solution per hour, the solution carrying from 0.1 to 0.8 ounce of gold per ton on entering the zinc box, and from 0.01 to 0.05 ounce on leaving it. The gold in wash waters and weaker solutions is less easily precipitated, a much longer contact with the zinc being required.

On cleaning up, the zinc shavings are washed and the finely powdered portions, called zinc-gold slimes, are screened through sieves varying in mesh, at the different mills, from one-fourth-inch mesh to 60-mesh, the coarse stuff being returned to the zinc box. In this country, where the zinc-gold slimes are treated at the mills, they are subjected to the action of an acid, such as sulphuric, which removes much of the zinc and other soluble bodies, and the residues are then washed, dried, fluxed, and melted. A few mills ship these slimes to smelters and refiners, but the difficulty of obtaining a satisfactory sample and the almost constant wide disagreement between buyer and seller have led many smelters to refuse to handle them.

In discussing Prof. Christy's paper Mr. Francis L. Bosqui stated* that at Bodie, Cal., after many discouraging failures, the following method of operating in treating the zinc-gold slimes was adopted, and has been followed with entire success:

"The slimes and fine zinc are discharged directly from the zinc boxes into a redwood vat 6 feet in diameter and 2 feet deep. This vat is protected on the inside by several coats of paraffin paint, has a slight bottom incline for drainage, and is provided with a 2-inch discharge valve. Here the slimes are treated with sulphuric acid. After the destruction of the zinc, the zinc sulphate and the slight excess of acid present are diluted by filling the vat with warm water. Within an hour the bulk of the precipitate will have settled to the bottom. The supernatant liquor, to the amount of about 400 gallons, which still contains a small amount of gold slimes in suspension, is then siphoned off into a 10-ton settling vat.

"The gold slimes are treated with a succession of these washes, the supernatant liquor being each time drawn off into the settling vat, until the amount of zinc sulphate remaining in the slimes is insignificant. The liquor siphoned off into the settling vat, which contains only a very small quantity of slimes in proportion to the total quantity obtained, is left to settle between clean-ups. The clear liquor is drawn off just before a succeeding clean-up, and at long intervals the precipitate is gathered from the bottom and melted.

"The bulk of the slimes is finally discharged from the acid vat into a filter box. This box is provided, about a foot from the top, with a perforated partition which is closely covered with two thicknesses of ordinary mill blanketing. From the compartment beneath this filter the air is withdrawn by means of a steam ejector, and the water is thus removed from the slimes by suction. At the bottom of the box is a one-inch discharge valve for drawing off the accumulated clear liquid. By occasionally scraping the filter blankets the passage of water through them is greatly facilitated. These blankets are removed and washed after each clean-up, and clean ones are substituted. The partially dried slimes from the blankets are then completely dried over a furnace and melted in crucibles. The zinc residues being thus pretty thoroughly removed from the slimes, the difficulties in melting are reduced to a minimum. . . .

"For some time a considerable value went into the slag, which had to be shipped to the smelting works. But after a good deal of experimentation a very suitable flux has been found, which reduces the slag value to almost nothing. A dust chamber has been constructed in connection with the melting furnace, and an effective damper introduced in the course of the flue. The latter is closed at each charging of the crucible, and 'dusting' is thus almost entirely avoided.

"Our loss in melting has never been more than barely appreciable, and now, since the introduction of a dust chamber and damper, is wholly insignificant. The wonderfully close correspondence between our actual bullion yield and the extraction indicated by careful assays of charged and discharged tailings would in itself weaken the supposition of any considerable loss in melting. To be sure, our bullion is low grade, but we suffer no inconvenience from this except the small increase in cost of transportation and refining in proportion to the value of the bars."

Precipitants other than filiform zinc are sometimes employed to throw down the gold. Thus, at the Delamar mine, Nevada, the precipitation is by zinc dust,† with agitation. Molloy precipitates with sodium or potassium amalgam, Moldenhauer with aluminium, Johnston with pulverized carbon, Christy with cuprous chloride, and De Wilde with cupric sulphate. Precipitation is effected also by electricity, amalgamated copper plates being used in the Pelatan-Clerici process, and thin lead plates as cathodes, with iron anodes, in the Siemens-Halske process.

Electro-deposition processes seem to possess an ad-

* Census Bulletin.

† Transactions of the American Institute of Mining Engineers, Vol. XXVI., pages 735 to 772.

* Transactions of the American Institute of Mining Engineers, Vol. XXVII., pages 837 to 846.

† S. F. Emmons, Transactions of the American Institute of Mining Engineers, Vol. XXXI., pages 658 to 683.

vantage over zinc precipitation processes in that the presence of caustic soda makes no difference in the result, and that they are as effective with a weak as with a strong solution. Very weak cyanide solutions may therefore be used in the leaching vats. Charles Butters, who has been closely identified with the development of the cyanide process from its introduction into this country in practical form, and has had extensive professional experience in South Africa, says* that in our more modern plants the electrolytic and zinc processes are now used in combination for the recovery of the metal from cyanide solutions. The solution is first cleaned by the electrolytic process. It extracts from 90 to 94 per cent of all the products, including practically all of the copper. About 8 to 9 per cent of the electric box capacity is then filled with zinc, which, aided by the electric current, removes the small quantities of gold and silver remaining. By this combination the zinc is constantly at its best, as everything that would injure the surface of the zinc as a precipitating surface has been eliminated by the previous electrolytic treatment. At Butters's mines, in Salvador, an extraction of about 99 per cent of the values in solution is made on regular monthly runs. This process is used also at Virginia City, Nev., and at Minas Prietas, Mexico.

The following tables from Packard's paper clearly set forth some of the variations which obtain in the use of the cyanide process with precipitation by zinc in practice, with results:

DESCRIPTION OF ORES USED IN CYANIDING, WITH PRECIPITATION BY ZINC.

Mill At.	Character.	Composition.					
		SiO_2.	Fe.	Al_2O_3.	$CaCO_3$.	S.	Other elements.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Mercur, Utah	Porphyry and limestone	70 to 80	....	5 to 10	....	....	As, Hg.
Sunshine, Utah	Decomposed porphyry and quartz	70 to 80	....	5 to 10	12 to 15	Little.	As, Sb, Te.
Bingham, Utah	Sandy quartz, with iron oxidized from sulphides and bunches of lead carbonate	....	....	....	Little.	....	As, 0.2 per cent; Cu; much free acid.
Gilt Edge, Mont	Porphyry and limestone	....	....	....	....	....	
Cooke, Mont	Decomposed porphyry	84	3.6	2.6	[1]0.6	0.3	
Black Hills, S. Dak	Silica, with iron in varying conditions	80 to 95	Varies.	....	....	Varies.	Traces of Cu, Mn, As, Sb.
Cripple Creek, Colo.	Porphyry	....	....	....	[2]1 to 3	Small.	Te.

[1] Calcium. [2] Calcium oxide.

METHODS OF TREATMENT AND RESULTS IN CYANIDING, WITH PRECIPITATION BY ZINC.

Mill at.	Capacity, tons per day.	Size of ore leached mesh.	Preliminary treatment.	Strength of cyanide solutions.	Number of hours leached.	Cyanide consumed per ton of ore treated.	Zinc consumed per ton of ore treated.	Assay of Ore.		Extraction of gold.	Cost per ton.
								Gold.	Silver.		
		Inches.		Per cent.		Pounds.	Pounds.	Ounces per ton.	Ounces per ton.	Per cent.	
Mercur, Utah	200	¾	None.	0.20 to 0.25	48	0.60	....	0.5 to 6.0	....	80 to 87	$0.85
Sunshine, Utah	60	¼	Lime.	0.06 to 0.20	48	0.75	0.30	....	....	....	....
Bingham, Utah	40	¼	Sodium dioxide.	0.025 to 0.125	120	1.0	0.30	0.25	2.0	80	1.85
Gilt Edge, Mont	50	20	None.	0.15	72	0.2	0.25	0.45	....	75	1.25
Cooke, Mont	25	16-20	Lime.	0.25	48	1.5 to 2.0	0.25	Variable.	....	....	....
Black Hills, S. Dak	40	30	Lime.	0.50 to 0.75	96	1.25	....	0.3 to 0.9	....	85	2.50
Cripple Creek, Colo.	75	40	Various, lime.	0.05 to 0.75	100	1.0 to 2.0	0.25 to 0.50	1.0	0.2	90	....

Mr. W. H. Davis has discovered that by subjecting foul cyanide solutions to the action of alternating electric currents the solutions are not only regenerated, owing to the precipitation of the foul matter present, but the resultant solution is more active and has a higher solvent power than a normal cyanide solution. He attributes this increased efficiency to cyanogen which has been set free in the electrolysis, being held dissolved in the solution. This process of treatment was introduced on a working scale at the Smuggler-Union mines, Colorado, in May, 1902, and it is claimed that by its use tailings carrying as low a value as $1.80 per ton have been treated at a profit, the average cost of treatment being 50 cents per ton. The published statement* of the manager of these mines, comparing the results of the operations for the four months preceding with those for the four months succeeding the introduction of this process for regenerating the foul solutions, states that the application of the process resulted in a reduction of 29.73 per cent in the quantity of potassium cyanide consumed and an increase of 17.09 per cent in the quantity of gold, and of 4.81 per cent in the quantity of silver extracted.

* Electro-Chemical Industry, Vol. II., page 207.

The results of simultaneous cyaniding, agitation, amalgamation, and electro-deposition are set forth in the following table, given by T. M. Chatard and Cabell Whitehead: †

In this connection it may be noted that in Wagner's Chemical Technology‡ there is described a method of treating refractory ores, invented by W. Crookes, which consists in subjecting the powdered ore to the action of an alternating current in the presence of a solution of mercuric cyanide or of some other soluble salt of mercury.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.§

SPARK LENGTH OF WIMSHURST MACHINE.—B. J. Palmer has studied the various ways in which the discharge from a Wimshurst machine may be forced, and the spark length increased. This may be done by drawing a small spark from the negative terminal, or holding a rod of insulating material near the positive terminal, by working another machine close by, or, lastly, by suddenly altering the shape of the terminal, or changing its size. The explanation may be sought in the surge or wave produced by any of these devices. In changing the size of the terminal, the effect is always greatest when the spark is taken from the larger ball and the disturbance carried over to the lesser; around the smaller the electromotive intensity is greatest, and this is greatly increased by the sudden change produced by the wave. For a ball of a given size there is a given electromotive intensity at which a brush is formed, and therefore a brush discharge is easiest formed on the smaller terminal; this by producing dissociated ions puts the gas in a condition in which it is electrically weaker, and if the distance is not too great a spark passes, otherwise only a brush is formed.—B. J. Palmer, Proceedings of the Cambridge Philosophical Society, May 24, 1905.

* Report of the Director of the Mint upon the Production of the Precious Metals during 1902, pages 99 to 101: 1903.

† Engineering and Mining Journal, Vol. LXIX., page 139.

‡ Manual of Chemical Technology, R. von Wagner, translated by W. Crookes, 1892, page 191.

§ Compiled by E. E. Fournier d'Albe in the Electrician.

A NEW RADIO-ACTIVE ELEMENT.—O. Hahn makes a preliminary communication with regard to the discovery of a new radio-active substance in the residue of thorianite. This residue was fused with carbonates, the silica was removed, and the carbonates dissolved in dilute hydrochloric acid. Lead was precipitated as sulphides, and the carbonates again precipitated. A residue of 18 grammes was thus obtained, and by a series of further operations the author obtained about 10 milligrammes of crystalline precipitate which was by far the most active preparation, and which shows after two months no diminution of its radio-active power. It glows feebly in the dark, and imparts bright luminosity to screens both of platino-cyanide and zinc sulphide. If a current of air be blown through a solution of this substance and directed on to a screen coated with zinc sulphide, luminosity is produced, which, nevertheless, is different in intensity from that shown when a similar experiment is performed with Giesel's emanium. The phenomena are not so brilliant as those obtained from a strong sample of emanium supplied by Prof. Giesel. It was not possible to perform the beautiful experiment of allowing the emanation to pour down on the screen and blowing it away, probably because the new substance emits β-rays in too great abundance. But that the dry substance also evolves emanation was easily discovered by help of an electrometer. This emanation is in all respects equal to thorium emanation, its half period being between 52 and 55 seconds. Yet it is certain that thorium itself was not present. This fact, coupled with the facts that inactive thoria is known to exist and that thorium emanation without thorium occurs at Baden-Baden, lead the author to believe that the new element is the active constituent of thorium.—O. Hahn, Proceedings of the Royal Society, No. 508, May 24, 1905.

RESULTS OF SIMULTANEOUS CYANIDING, AGITATION, AMALGAMATION, AND ELECTRO-DEPOSITION.

Ore Used.	Screen mesh.	Length of run.	Ore Assay.		Tailings Assay.		Extraction.		Strength of Cyanide Solution.			Electric Current.	
			Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Start.	End.	Loss.	Volts.	Amperes per square foot.
		Min.	Ounces.	Ounces.	Ounces.	Ounces.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		
Heavy (60 per cent) sulphuret ore, North Carolina	60	75	1.075	1.23	0.20	0.60	81.41	51.00	0.131	0.064	0.067	1.85	0.20
Telluride ore, oxidized, very slimy, Cripple Creek, Colo	60	60	0.90	0.60	0.10	0.35	88.90	42.00	0.190	0.155	0.035	2.10	0.17
	60	45	0.90	0.60	0.10	0.45	88.90	33.00	0.184	0.152	0.032	2.01	0.23
Telluride, like No. 2, Cripple Creek, Colo	60	60	0.95	0.65	0.12	0.38	87.47	41.51	0.185	0.134	0.051	2.20	0.26
	60	60	0.95	0.65	0.07	0.28	92.63	56.92	0.250	0.164	0.086	2.30	0.23
Telluride oxidized, dark red, very slimy, Cripple Creek, Colo	60	60	4.55	1.45	0.12	0.38	97.38	73.80	0.163	0.081	0.082	1.01	0.18
	60	75	4.55	1.45	0.10	0.25	97.81	82.76	0.164	0.129	0.035	1.80	0.19
Heavy sulphuret, Boulder County, Colo	60	60	0.40	1.30	0.12	0.60	70.00	54.60	0.150	0.059	0.091	2.02	0.22
Heavy sulphuret, South America[1]	60	60	1.05	4.35	0.60	2.55	42.85	41.38	0.180	0.078	0.102	2.02	0.23
Republic Mine, Washington	60	60	6.30	6.15	2.10	2.80	66.66	54.49	0.287	0.201	0.086	2.10	0.26
Republic Mine, finer ground	80	75	6.30	6.15	1.45	1.90	77.00	60.13	0.289	0.209	0.080	2.30	0.21
Republic Mine, still finer	100	75	6.30	6.15	0.48	1.02	92.38	83.41	0.231	0.164	0.067	2.63	0.14
Rich ore, Virginia, contains galena, etc	100	90	33.98	....	1.66	....	95.05	....	0.292	0.185	0.107	2.78	0.73
Republic Mine, Washington, mill pulp	100	90	2.50	3.75	0.40	1.55	84.60	60.00	0.170	0.105	0.065	3.27	0.67
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.25	0.75	90.00	79.20	0.245	0.190	0.055	3.03	0.67
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.20	2.25	92.00	40.00	0.320	0.225	0.095	3.10	0.50
Republic Mine, Washington, mill pulp	100	60	2.50	3.75	0.135	1.36	94.60	63.60	0.277	0.202	0.075	3.00	0.50
Republic Mine, Washington, coarse ore	60	60	2.30	2.50	0.375	1.025	83.70	58.80	0.198	0.099	0.099	No meter.	0.45
Republic Mine, Washington, coarse tailings	100	60	0.45	1.30	0.25	1.125	44.44	13.46	0.117	0.080	0.037	3.00	0.31
Republic Mine, Washington, coarse tailings	100	90	0.45	1.30	0.25	1.10	44.44	15.37	0.155	0.095	0.056	No meter.	0.48
Rough mill concentrates, Georgia	40	90	0.80	0.50	0.125	0.37	84.37	26.00	0.149	0.093	0.056	No meter.	0.48
Sulphuret ore, Georgia	40	90	2.68	1.00	0.27	0.50	89.92	50.00	0.276	0.214	0.062	2.8	0.57
Silver ore, Honduras[2]	100	90	0.71	72.86	0.10	6.00	85.91	91.76	0.263	0.175	0.088	4.0	0.84
Free quartz, California	100	90	0.475	0.92	0.05	0.525	89.49	41.02	0.235	0.140	0.095	2.6	0.94

[1] Contained Arsenic and Antimony. [2] Contained Silver Chloride.

[Continued from SUPPLEMENT No. 1544, page 24747.]

THE CONSTRUCTION OF A SILVERED GLASS TELESCOPE, FIFTEEN AND A HALF INCHES IN APERTURE, AND ITS USE IN CELESTIAL PHOTOGRAPHY.—III.

By HENRY DRAPER, M.D., Professor of Natural Science in the University of New York.*

§ 2. THE TELESCOPE MOUNTING.

THE telescope is mounted as an altitude and azimuth instrument, but in a manner that causes it to differ from the usual instrument of that kind. The essential feature is, that *the eye-piece or place of the sensitive plate is stationary at all altitudes*, the observer

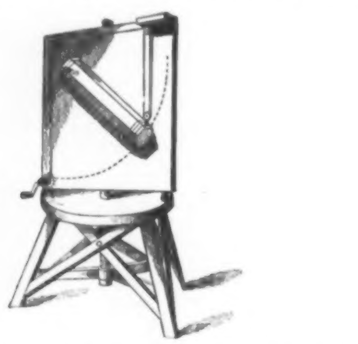


FIG. 27.—MISS HERSCHEL'S TELESCOPE.

always looking straight forward, and never having to stoop or assume inconvenient and constrained positions.

The stationary eye-piece mounting was first used by Miss Caroline Herschel, who had a 27-inch Newtonian arranged on that plan. Fig. 27. (Smyth's Celestial Cycle.)

Subsequently it was applied to a large telescope by Mr. Nasmyth, the eminent engineer, but no details of his construction have reached me. He used it for making drawings of the moon, which are said to be excellently executed.

When it became necessary to determine how my telescope should be mounted, I was strongly urged to make it an equatorial. But after reflecting on the fact that it was intended for photography, and that absolute freedom from tremor was essential, a condition not attained in the equatorial when driven by a clock, and in addition that in the case of the moon rotation upon a polar axis does not suffice to counteract the motion in declination, I was led to adopt the other form.

A great many modifications of the original idea have been made. For instance, instead of counterpoising the end of the tube containing the mirror by extending the tube to a distance beyond the altitude or horizontal axis, I introduced a system of counterpoise levers which allows the telescope to work in a space little more than its own focal length across. This construction permits both ends of the tube to be supported, the lower one on a wire rope, and gives the greatest freedom from tremor, the parts coming quick-

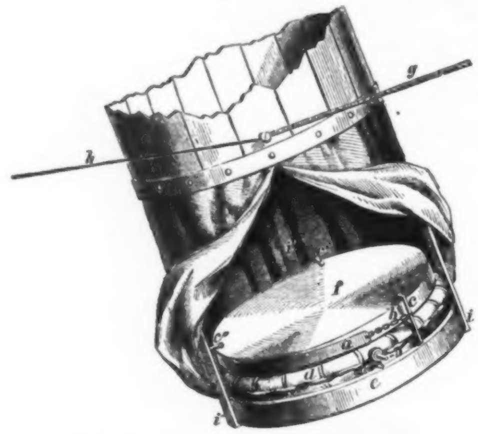


FIG. 29.—THE MIRROR SUPPORT.

ly to rest after a movement. In the use of the telescope for photography, as we shall see, the system of bringing the mass of the instrument to complete rest before exposing the sensitive plate, and only driving that plate itself by a clock, is always adopted.

The obvious disadvantage connected with the alt-azimuth mounting—the difficulty of finding some objects—has not been a source of embarrassment. In fact the instability of the optical axis in reflecting instruments, if the mirror is unconstrainedly supported, as it should be, renders them unsuitable for determinations of position. A little patience will enable an observer to find all necessary tests, or curious objects.

The mounting is divided into: a. The Tube; and b. The supporting frame.

a. The Tube.

The telescope tube is a sixteen-sided prism of walnut wood, 18 inches in diameter, and 12 feet long. The staves are ⅝ of an inch thick, and are hooped together with four bands of brass, capable of being tightened by screws. Inside the tube are placed two rings of iron, half an inch thick, reducing the internal diameter to about 16 inches. At opposite sides of the upper end of the tube are screwed the perforated trunnions *a*, Fig. 28 (of which only one is shown), upon which it swings. Surrounding the other end is a wire rope *b b′ b″*, the ends of which go over the pulleys *c* (*c′* not shown) on friction rollers, and terminate in disks of lead *d d′*. These counterpoises are fastened on the ends of levers *e e′*, which turn below on a fixed axle *f*.

By this arrangement, as the tube assumes a horizontal position and becomes, so to speak, heavier, the counterpoises do the same, while when the tube becomes perpendicular, and most of its weight falls

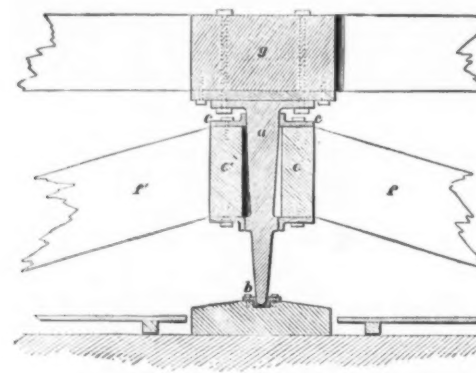


FIG. 30.—SECTION OF AZIMUTH AXIS.

upon the trunnions, the counterpoises are carried mostly by their axle. A continual condition of equilibrium is thus reached, the tube being easily raised or depressed to any altitude desired. It is necessary, however, to constrain the wire rope *b b′ b″*, to move in the arc of the circle described by the end of the tube and ends of the levers, and hence the twelve rollers or guide pulleys *g g′ g″*. Over some of the same pulleys a thin wire rope *h h′* runs, but while its ends are fastened to the lower part of the tube at *b*, the central parts go twice around a roller connected with the winch *i*, near the eye-piece, thus enabling the observer to move the telescope in altitude, without taking the eye from the eye-piece.

The iron wire rope required to be carefully made, so as to avoid rigidity. It contains 2 1-3 miles of wire, 1-100 of an inch in diameter, and has 300 strands. Each single wire will support 7 pounds. It is, however, more flexible than a hempen rope of the same size, owing to its loose twisting.

At the lower end of the tube, at the distance of a foot, and crossing it at right angles, held by three bars of iron *i i′ i″*, Fig. 29, is a circular table of oak *e*, which carries an India-rubber air sac *d*, and upon

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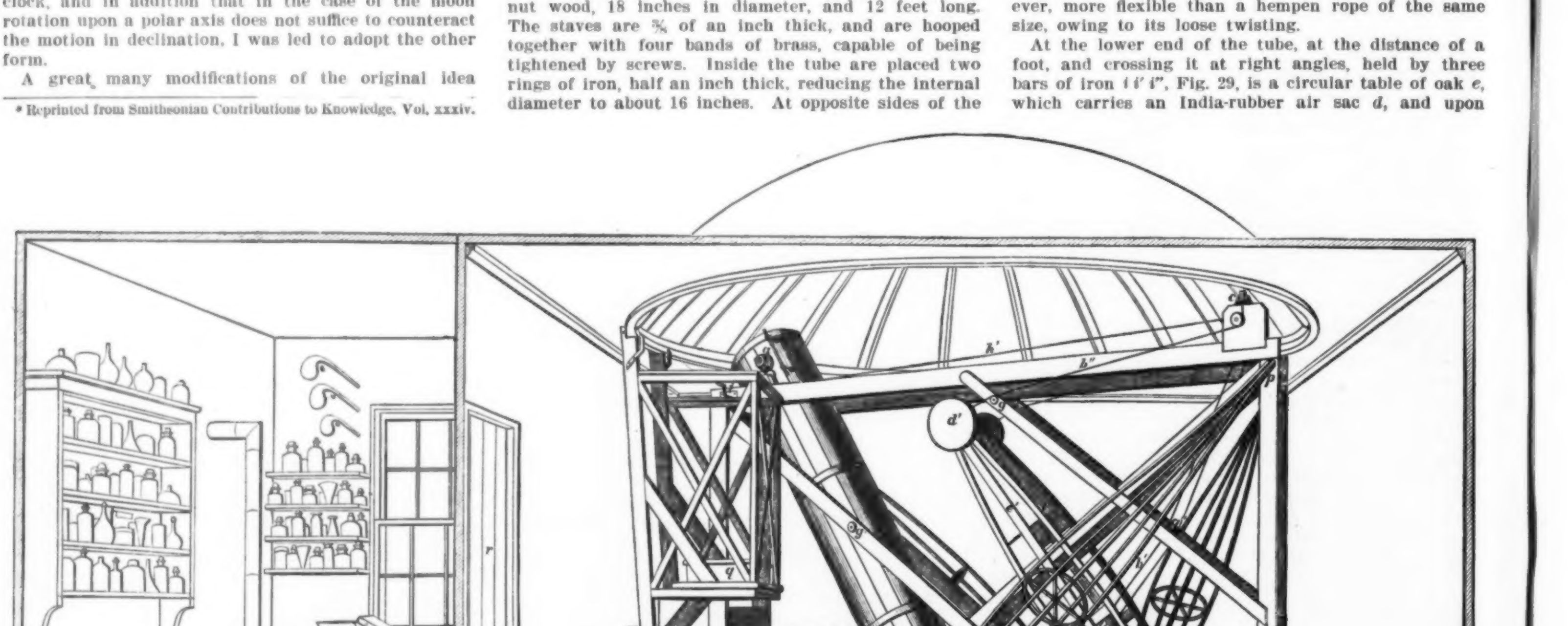

FIG. 28.—SECTIONAL VIEW OF OBSERVATORY.

this the mirror f is placed. The edge support of the mirror is furnished by a semicircular band of tinplate a, lined inside with cotton, and fastened at the ends by links of chain b, (b' not seen) to two screws $c\,c'$; g and h are the wire ropes, marked b and h in Fig. 28.

Instead of the blanket support which Herschel found so advantageous, M. Foucault has suggested this use of an air sac. In his instrument there is a tube going up to the observer, by which he may adjust its degree of inflation. It requires that there should be three bearings, $c\,c'\,c''$, in front of the mirror, against which it may press when the sac behind is inflated, otherwise the optical axis is altogether too unstable, and objects cannot be found. The arrangement certainly gives beautiful definition, bringing stars to a disk when the glass just floats, without touching its front bearings. The first sac that I made was composed of two circular sheets of India-rubber cloth, joined around the edges. But this could not be used while photographing, because the image was kept in a state of continuous oscillation if there was a breeze, and even under more favorable circumstances took a long time to come to rest. It was not advisable to blow the mirror hard up against its three front bearings, in order to avoid the instability, for then every point of an object became triple. To the eye the oscillations were not offensive, because the swaying image was sharp.

Subsequently, however, an air chair cushion was procured, and as the surface was flat instead of convex the difficulty became so much less that the blanket support was definitely abandoned. It is necessary that the mirror should have free play in the direction of the length of the tube when this kind of support is used, and that is the reason why the tin edge hoop must terminate in links of chain.

The interval, eight or ten inches, which separates the face of the mirror from the tube, is occupied by a curtain of black velvet, confined below by a drawing cord and tacked above to the tube. This permits access to the mirror to put a glass cover on it, and when shut down stops the current of air rushing up. When the instrument is not being used this curtain is left open, because the mirror and tube are in that case kept more uniform in temperature with the surrounding air.

In spite of such contrivances there is still sometimes a strong residual current in the tube. I have tried to overcome it by covering the mouth of the tube with a sheet of flat glass, but have been obliged to abandon that because the images were injured. At one time, too, when it was supposed that the current was partly from the observer's body, heated streams of air going out around the tube, the aperture in the dome was closed by a conical bag of muslin, which fitted the mouth of the telescope tightly. The only advantages resulting were mere bodily comfort and a capability of perceiving fainter objects than before, because the sky light was shut off.

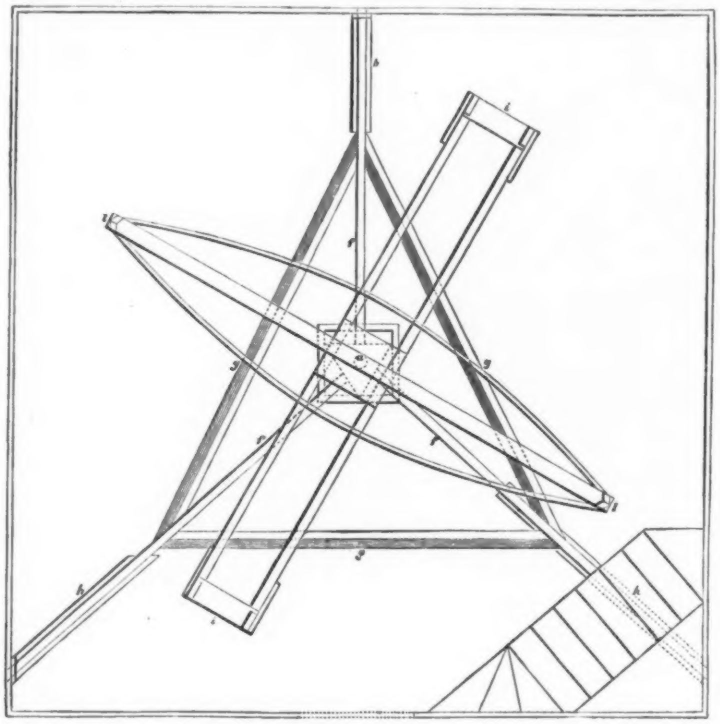

FIG. 31.—PLAN OF OBSERVATORY (LOWER FLOOR).

b. The Supporting Frame.

The frame which carries the preceding parts is of wood, and rests on a vertical axis, a, Fig. 30, turning below in a gun-metal cup, b, supported by a marble block resting on the solid rock. The upper end of the axis is sustained by two collars, one $c\,c'$ above, and the other below an intermediate triangular box $e\,e'$ from the sides of which three long beams $f\,f\,f$ 12 × 3 inches diverge, gradually declining till they meet the solid rock at the limits of the excavation in which the observatory is placed. These beams are fastened together by cross-pieces, $g\,g\,g$, Fig. 31, and go through the floor in spaces $h\,h\,h$, so contrived that the floor does not touch them. At the ends they are cased with a thick leaden sheathing, to deaden vibration and prevent the access of moisture.

This tripod support in connection with the sustaining of the telescope by the wire rope, gives that steadiness which is so essential in photography. Only a slight amount of force, about two pounds, is required to move the instrument in azimuth, though it weighs almost a thousand pounds.

The plan of the frame centrally carried by the axis a is as follows: From the corners of a parallelogram $i\,i$ (2 × 13 feet) of wooden beams, eight inches thick and three inches broad, perpendiculars $n\,n'$, Fig. 28, rise. At the top they are connected by lighter pieces to form a parallelogram, similar to that below, and just large enough to contain the tube of the telescope. At right angles to the parallelogram below, and close upon it, a braced bar, $o\,o'$, Fig. 28, crosses. From its extremities four slanting braces as at $p\,p'$, Fig. 28, go to the corners of the upper parallelogram, and combine to give it lateral support. At the top of one close pair of the perpendiculars n', Fig. 28, are bronze frames carrying friction rollers upon which the trunnions move, while similarly upon the other pair n are two pulleys, also on friction rollers, for the wire rope coming from the counterpoises.

Movement in altitude is very easily accomplished, and with the left hand upon the winch i, under high powers, both altitude and azimuth motions are controlled, and the right hand left free. The whole apparatus works so well, that in ordinary observation the want of a clock movement has not been felt. Of course for photography that is essential.

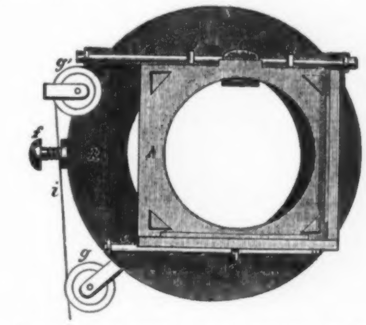

FIG. 32.—SLIDING PLATE-HOLDER.

§3. THE CLOCK MOVEMENT.

The apparatus for following celestial bodies is divided into two parts: a. The Sliding Plate-holder; and b. The Clepsydra. In addition a short description of the Sun-Camera, c, is necessary.

a. The Sliding Plate-holder.

Mr. De La Rue, who has done so much for celestial photography, was the first to suggest photographing the moon on a sensitive plate, carried by a frame moving in the apparent direction of her path. He never, however, applied an automatic driving mechanism, but was eventually led to use a clock which caused the whole telescope to revolve upon a polar axis, and thus compensate for the rotation of the earth, and on certain occasions for the motion of the moon herself. In this way he has produced the best results that have been obtained in Europe. Lord Rosse, too, employed a similar sliding plate-holder, but provided with clockwork to move it at an appropriate rate. I have not been able as yet to procure any precise account of either of these instruments.

The first photographic representations of the moon ever made were taken by my father, Prof. John W. Draper, and a notice of them published in his quarto work "On the Forces that Organize Plants," and also in the September number, 1840, of the London Edinburgh, and Dublin Philosophical Magazine. He presented the specimens to the New York Lyceum of Natural History. The secretary of that association has sent me the following extract from their minutes:

"March 23d, 1840. Dr. Draper announced that he had succeeded in getting a representation of the moon's surface by the daguerreotype. . . . The time occupied was 20 minutes, and the size of the figure about 1 inch in diameter. Daguerre had attempted the same thing, but did not succeed. This is the first time that anything like a distinct representation of the moon's surface has been obtained.

"ROBT. H. BROWNNE, Secretary."

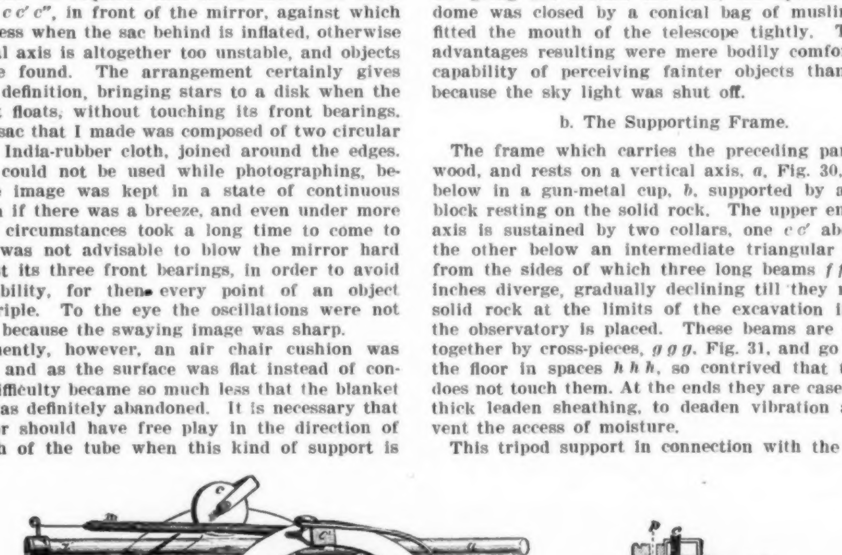

FIG. 33.—FRICTIONLESS SLIDE (FRONT VIEW). SECTIONAL VIEW.

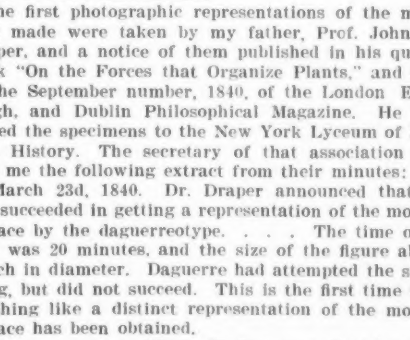

FIG. 34.—THE SAND-CLOCK.

As my father was at that time, however, much occupied with experiments on the chemical action of light, the influence of light on the decomposition of carbonic acid by plants, the fixed lines of the spectrum, spectrum analysis, etc., the results of which are to be found scattered through the Philosophical Magazine, Silliman's Journal, and the Journal of the Franklin Institute, he never pursued this very promising subject. Some of the pictures were taken with a

three-inch, and some with a five-inch lens, driven by a heliostat.

In 1850, Mr. Bond, taking advantage of the refractor of 15 inches aperture at Cambridge, obtained some fine pictures of the moon, and subsequently of double stars, more particularly Mizar in Ursa Major. The driving power, in this instance, was also applied to move the telescope upon a polar axis.

Besides these, several English and continental observers, Messrs. Hartnup, Phillips, Crookes, Father Secchi, and others, have worked at this branch of astronomy and, since 1857, Mr. Lewis M. Rutherfurd, of New York, has taken many exquisite lunar photographs, which compare favorably with foreign ones.

But in none of these instances has the use of the sliding plate-holder been persisted in, and its advantages brought into view. In the first place it gets rid completely of the difficulties arising from the moon's motion in declination, and in the second, instead of injuring the photograph by the tremors produced in moving the whole heavy mass of a telescope weighing a ton or more, it only necessitates the driving of an arrangement weighing scarcely an ounce.

My first trials were with a frame to contain the sensitive plate, held only at three points. Two of these were at the ends of screws to be turned by the hands, and the third was on a spring so as to maintain firm contact. This apparatus worked well in many respects, but it was found that however much care might be taken, the hands always caused some tremor in the instrument. It was evident then that the difficulty from friction which besets the movements of all such delicate machinery, and causes jerking and starts, would have to be avoided in some other way.

I next constructed a metal slide to run between two parallel strips, and ground it into position with the greatest care. This, when set in the direction of the moon's apparent path, and moved by one screw, worked better than the preceding. But it was soon perceived that although the strips fitted the frame as tightly as practicable, an adhesion of the slide took place first to one strip and then to the other, and a sort of undulatory or vermicular progression resulted. The amount of deviation from a rectilinear motion, though small, was enough to injure the photographs. At this stage of the investigation the regiment of volunteers to which I belonged was called into active service, and I spent several months in Virginia.

My brother, Mr. Daniel Draper, to whose mechanical ingenuity I have on several occasions been indebted for assistance in the manifold difficulties that have arisen while constructing this telescope, continued these experiments at intervals. He presented me on my return with a slide and sand-clock, with which some excellent photographs have been taken. He had found that unless the slide above mentioned was made ungovernably long, the same trouble continued. He then ceased catching the sliding frame *h*, Fig. 32, by two opposite sides, and made it run along a single steel rod *a*, being attached by means of two perforated plates of brass *b*, *b'*. The cord *i* going to the sand-clock, was applied so as to pull as nearly as possible in the direction of the rod. A piece of cork, *c*, gave the whole steadiness, and yet softness of motion. The lower end of the frame was prevented from swinging back and forward by a steel pin *d*, which played along the glass rod *e*. All these parts were attached to a frame *k*, fitting on the eyepiece holder, and permitting the rod *a* to change from the horizontal position in which it is here drawn, to any angular one desired. The thumb-screw *f* retained it in place; *g* and *g'* are pulleys which permit the cord to change direction.

Subsequently, a better method of examining the uniformity of the rate, than by noticing the sharpness of the photograph produced, was invented. It consists in arranging a fixed microscope, magnifying about forty times, at the back of the ground glass plate, which fits in the same slide as the sensitive plate. By watching the granulated appearance pass before the eye, as the slide is moved by the clock, the slightest variation from uniformity, any pulsatile or jerking movement, is rendered visible. By the aid of this microscopic exaggeration, it was seen that occasionally, when there had been considerable changes in temperature, the steadiness of the motion varied. This was traced to the irregular slipping of *b*, *b'*.

A different arrangement was then adopted, by which a lunar crater can be kept bisected as long as is necessary, and which gives origin to no irregularities, but pursues a steady course. The principle is, not to allow a slipping friction anywhere, but to substitute rolling friction, upon wheels turning on points at the ends of their axles. The wood-cut, Fig. 33, is half the real size of this arrangement.

A glass rod, *a a'*, Fig. 33, is sustained by two wheels, *b b'*, and kept in contact with them by a third friction roller, *c*, pressed downward by a spring. This rod carries a circular frame, *d d'*, upon which at *e e' e''*, are three glass holders and platinum catches. A spring *f* holds the sensitive plate in position, by pressing against its back. The circular frame *d* is kept in one plane by a fourth friction roller, *g*, which runs on a glass rod, *h*, and is kept against it by the inward pressure of the overhanging frame, *d*. The cord *i* is attached to the arm *k*, and pulls in the direction of the glass rod *a*. From *m* to a fixed point near *b*, a strip of elastic India-rubber is stretched, to keep the cord tight. The ring of brass, *n n'*, carries the whole, serving as a basis for the stationary parts, and in its turn being fastened to the eyepiece holder, so as to allow the glass rod *a* to change direction, and be brought into coincidence with the apparent path of the moon. At *o* is a thumb-screw or clamp. Through the ring *n n'*, a groove, *p*, is cut, into which a piece of yellow glass may be placed, when the actinic rays are to be shut off from the plate.

Since this contrivance has been completed, all the previous difficulties have vanished. The moving of a plate can be accomplished with such precision, that when the atmosphere was steady, negatives were taken which have been enlarged to three feet in diameter.

The length of time that such a slide can be made to run is indefinite, depending in my case on the size of the diagonal flat mirror, and aperture of the eyepiece

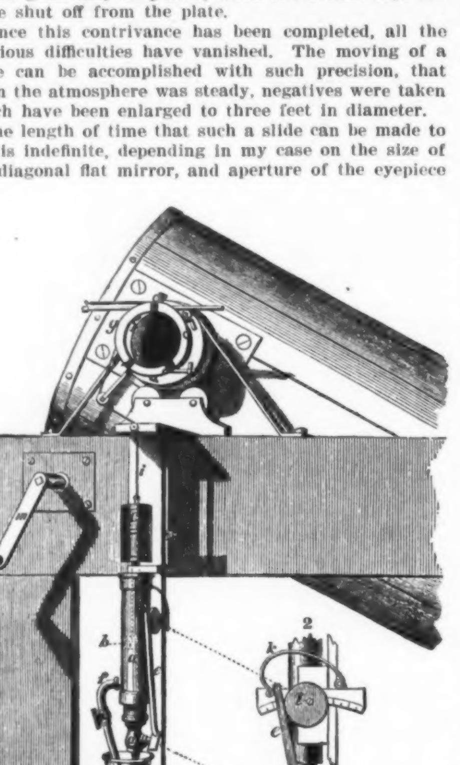

Fig. 35.—THE CLEPSYDRA.

holder. I can follow the moon for nearly four minutes, but have never required to do so for more than fifty seconds. At the mouth of the instrument, where no secondary mirror is necessary, the time of running could be increased.

The setting of the frictionless slide in angular position is accomplished as follows: A ground glass plate is put into it, with the ground face toward the mirror. Upon this face a black line must have been traced, precisely parallel to the rod *a*. This may be accomplished by firmly fixing a pencil point against the ground side, and then drawing the frame *d* and glass past it, while the rest of the slide is held fast. As the moon passes across the field, the position of the apparatus must be changed, until one of the craters runs along the line from end to end. A cross line drawn perpendicular to the other serves to adjust the rate of the clepsydra as we shall see, and when a crater is kept steadily on the intersection for twice or three times the time demanded to secure an impression, the adjustment may be regarded as complete.

It is necessary of course to expose the sensitive plate soon after, or the apparent path of the moon will have changed direction, unless indeed the slide is set to suit a future moment.

b. The Clepsydra.

My prime mover was a weight supported by a column of sand, which, when the sand was allowed to run out through a variable orifice below, could be made to descend with any desired velocity and yet with uniformity. In addition, by these means an unlimited power could be brought to bear, depending on the size of the weight. Previously it was proposed to use water, and compensate for the decrease in flow, as the column shortened, by a conical vessel; but it

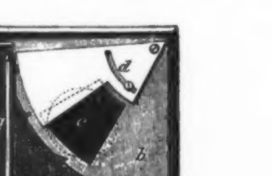

Fig. 36.—THE SPRING SHUTTER.

was soon perceived that as each drop of water escaped from the funnel-shaped vessel, only a corresponding weight would be brought into play. This is not the case with sand, for in this instance every grain that passes out causes the whole weight that is supported by the column to come into action. In the former instance a movement consisting of a series of periods of rest and periods of motion occurs, because power has to accumulate by floating weight lagging behind the descending water, and then suddenly overtaking it. In the latter case, on the contrary, there is a regular descent, all minor resistances in the slide being overcome by the steady application of the whole mass of the weight.

When these advantages in the flow of sand were ascertained, all the other prime movers were abandoned. Mercury-clocks, on the principle of the hydrostatic paradox, air-clocks, etc., in great variety, had been constructed.

The sand-clock consisted of a tube *a* (Fig. 34), eighteen inches long and one and a half in diameter, nearly filled with sand that had been raised to a bright red heat and sifted. Upon the top of the sand a leaden weight, *b*, was placed. At the bottom of the tube a peculiar stopcock, seen at (2) enlarged, regulated the flow, the amount passing depending on the size of the aperture *d*. This stopcock consisted of two thin plates, fixed at one end and free at the other. The one marked *e* is the adjusting lever, and its aperture moves past that in the plate *g*. The lever *f* serves to turn the sand off altogether, without disturbing the size of the other aperture, which, once set to the moon's rate, varies but slightly in short times. A movable cover, *h*, perforated to allow the cord *i* to pass through, closed the top, while the vessel *k* retained the escaped sand, which at suitable times was returned into the tube *a*, the weight *b* being temporarily lifted out. From the clock the cord *i* communicated motion to the frictionless slide, as shown in Fig. 33. This cord should be as inelastic as possible, consistent with pliability, and well waxed.

One who has not investigated the matter would naturally suppose that the flow of sand in such a long tube would be much quicker when the tube was full than when nearly empty, and that certainly that result would occur when a heavy weight was put on the shifting mass. But in neither case have I been able to detect the slightest variation, for, although by shaking the tube a diminution of the space occupied by the sand may be caused, yet no increase of weight tried could accomplish the same reduction. These peculiarities seem to result from the sand arching as it were across the vessel, like shot in a narrow tube, and only yielding when the under supports are removed. In blasting, a heavy charge of gunpowder can be retained at the bottom of a hole, and made to split large masses of rock, by filling the rest of the hole with dry sand.

I believe that no prime mover is more suitable than a sand-clock for purposes where steady motion and a large amount of power are demanded. The simplicity, for instance, of a heliostat on this plan, the large size it might assume, and its small cost, would be great recommendations. In these respects its advantages over wheelwork are very apparent. The precision with which such a sand-clock goes may be appreciated when it is stated that under a power of 300 a lunar crater can be kept bisected for many times the period required to photograph it. To secure the greatest accuracy in the rate of a sand-clock, some precautions must be taken. The tube should be free from dents, of uniform diameter, and very smooth or polished inside. Water must not be permitted to find access to the sand, and hygrometric varieties of that substance should be avoided, or their salts washed out. The sand should be burned to destroy organic matter, and so sifted as to retain grains nearly equal in size. The weight, which may be of lead, must be turned so as to go easily down the tube, and must be covered with writing paper or some other hard and smooth material, to avoid the proneness to adhesion of sand. A long bottle filled with mercury answers well as a substitute.

I have used in such clocks certain metallic preparations: Fine shot, on account of its equality of size, might do for a very large clock with a considerable opening below, but is unsuitable for a tube of the size stated above. There is, however, a method by which lead can be reduced to a divided condition, like fine gunpowder, when it may replace the sand. If that metal is melted with a little antimony, and while cooling is shaken in a box containing some plumbago, it breaks up at the instant of solidifying into a fine powder, which is about five times as heavy as sand. If after being sifted to select the grains of proper size, it is allowed to run through a small hole, the flow is seen to be entirely different from that of sand, looking as if a wire or solid rod were descending, and not an aggregation of particles. It is probable, therefore, that it would do better than sand for this purpose. I have not, however, given it a fair trial, because just at the time when the experiments with the sand-clock had reached this point, I determined to try a clepsydra as a prime mover.

The reason which led to this change was that it was observed on a certain occasion when the atmosphere was steady, that the photographs did not correspond in sharpness, being in fact no better than on other nights when there was a considerable flickering motion in the air. A further investigation showed that in these columns of sand there is apt to be a minute vibrating movement. At the plate-holder above this is converted into a series of arrests and advances. On some occasions, however, these slight deviations from continuous motion are entirely absent, and generally, indeed, they cannot be seen, if the parts of the image seem to vibrate on account of currents in the air. By the aid of the microscopic exaggeration already described—which was subsequently put in practice—they may be observed easily, if present.

When the negative produced at the focus of the great mirror is intended to be enlarged to two feet or more in size, these movements injure it sensibly. A variety of expedients was resorted to in order to avoid them, but none proved on all occasions successful.

It is obvious that in a water-clock, where the mobility of the fluid is so much greater than that of solid grains, this difficulty would not arise. The following contrivance in which the fault of the ordinary clepsydra in varying rate of flow as the column shortens is avoided, was next made. With it the best results are attainable, and it seems to be practically perfect.

It consists of a cylinder *a*, in which a piston *b* moves watertight. At the top of the piston rod is a leaden five-pound weight *c*, from which the cord *i* goes to the sliding plate-holder *g*. The lower end of the cylinder terminates in a stopcock *d*, the handle of which carries a strong index rod *e*, moving on a divided arc. At *f* a tube with a stopcock is attached. Below, a vessel, *h*, receives the waste fluid.

In using the clepsydra the stopcock of *f* is opened, and the piston being pulled upward, the cylinder fills with water from *h*. The stopcock is then closed, and if *d* also is shut, the weight will remain motionless. The string *i* is next connected with the slide, and the telescope turned on the moon. As soon as the slide is adjusted in angular position the stopcock *d* is opened, until the weight *c* moves downward at a rate that matches the moon's apparent motion.

In order to facilitate the rating of the clepsydra, the index rod *e* is pressed by a spring *k* (2), against an eccentric *l*. As the eccentric is turned round, the stopcock *d* is of course opened, with great precision and delicacy. The plug of this stopcock (3) is not perforated by a round hole, but has a slit. This causes equal movements in the rod *e* to produce equal changes in the flow. The rating requires consequently only a few moments.

The object of the side tube *f* is to avoid disturbing *d* when it becomes necessary to refill the cylinder, for when it is once opened to the right degree, it hardly requires to be touched again during a night's work. In order to arrest the downward motion of the piston at any point, a clamp screws on the piston rod, and can be brought into contact with the cylinder head, as in the figure.

That this instrument should operate in the best manner, it is essential to have the interior of the brass cylinder polished from end to end, and of uniform diameter. If any irregularity should be perceived in the rate of going, it can be cured completely by taking out the piston, impregnating its leather stuffing with fine rotten stone and oil, and then rubbing it up and down for five minutes in the cylinder, so as to restore the polish. The piston and cylinder must of course be wiped, and regreased with a mixture of beeswax and olive oil (equal parts) after such an operation. In replacing the piston, the cylinder must be first filled with water, to avoid the presence of air, which would act as a spring.

Although it may be objected that this contrivance seems to be very troublesome to use, yet that is not the case in practice. Even if it were, it so far surpasses any prime mover that I have seen, where the utmost accuracy is needed, that it would be well worth employing.

c. The Sun Camera.

In taking photographs of the sun with the full aperture of this telescope, no driving mechanism is necessary. On the contrary, the difficulty is rather to arrange the apparatus so that an exposure short enough may be given to the sensitive plate, and solarization of the picture avoided. It is not desirable to reduce the aperture, for then the separating power is lessened. The time required to obtain a negative is a very small fraction of a second, for the wavy appearance produced by atmospheric disturbance is not unfrequently observed sharply defined in the photograph, though these aerial motions are so rapid that they can scarcely be counted. Some kind of shutter that can admit and cut off the solar image with great quickness is therefore necessary.

In front of an ordinary camera, *a*, Fig. 36, attached to the eyepiece holder of the telescope, and from which the lenses have been removed, a spring shutter is fixed. It consists of a quadrant of thin wood *b*, fastened by its right angle to one corner of the camera. Over the whole in this quadrant a plate of tin, *d*, can be adjusted, and held in position by a screw moving in a slot so as to reduce the hole if desired to a mere slit. It may vary from 1½ inch to less than 1-50 of an inch. The quadrant is drawn downward by an India-rubber spring, *g*, 1 inch wide, ⅛ of an inch thick, and 8 inches long. This spring is stretched when in action to about 12 inches, and when released draws the slit past the aperture *c* in the camera. Two nicks in the edge of the quadrant serve with the assistance of a pin, *e*, which can easily be drawn out by a lever (not shown in the cut), to confine the slit either opposite to or above *c*. A catch at *f* prevents the shutter recoiling. The sensitive plate is put inside the box as usual in a plate-holder. When a photograph is taken, the spring shutter is drawn up so that the lower nick in the edge of the quadrant is entered by the pin *e*, and the inside of the camera obscured. The front slide of the plate-holder is then removed in the usual manner, and the solar image being brought into proper position by the aid of the telescope finder, the trigger retaining *e* is touched, the shutter flies past *c*, and the sensitive plate may then be removed to be developed.

To avoid the very short exposure needed when a silvered mirror of 188 square inches of surface is used, I have taken many solar photographs with an unsilvered mirror, which only reflects according to Bouguer 2½ per cent of the light falling upon it, and should permit an exposure 37 times as long as the silvered mirror. This is the first time that a plain glass mirror has been used for such a purpose, although Sir John Herschel suggested it for observation many years ago. But eventually this application of the unsilvered mirror had to be abandoned. It has, it is true, the advantage of reducing the light and heat, but I found that the moment the glass was exposed to the sun, it commenced to change in figure, and alter in focal length. This latter difficulty, which sometimes amounts to half an inch, renders it well-nigh impossible to find the focal plane, and retain it while taking out the ground glass, and putting in the sensitive plate. If the glass were supported by a ring around the edge, and the back left more freely exposed to the air, the difficulty would be lessened but not avoided, for a glass mirror can be raised to 120 deg. F. on a hot day by putting it in the sunshine, though only resting on a few points. Other means of reducing the light and heat, depending on the same principle, can, however, be used. By replacing the silvered diagonal mirror with a black glass or plain unsilvered surface, as suggested by Nasmyth, the trouble sensibly disappears.

I have in this way secured not only maculæ and their penumbræ, but also have obtained faculæ almost invisible to observation. On some occasions, too, the precipitate-like or minute flocculent appearance on the sun's disk was perceptible.

It seems, however, that the best means of acquiring fine results with solar photography, would be to use the telescope as a Cassegranian, and produce an image so much enlarged that the exposure would not have to be conducted with such rapidity. Magnifying the image by an eyepiece would in a general way have the same result, but in that case the photographic advantages of the reflector would be lost, and it would be no better than an achromatic.

(To be continued.)

SCIENCE NOTES.

The problem of the supply of capital in agriculture has never been solved in this country other than in the most expensive way. Capital must return to the land. Two factors enter into the problem: (1) to demonstrate that capital can be made remunerative in farmed land, (2) to insure that land will not bear an unjust burden of taxation. Closely associated with the economic side is the sociological phase. In the days when all were interested in agriculture, both school and church flourished, but in these later days both have lost their molding influence in the country, though the former shows signs of renewed activity vital to the community.

Castor oil is now extensively used in countries which manufacture large quantities of calicoes and colored cotton goods. The United Kingdom is the greatest European consumer, and of the other principal consuming countries the United States ranks easily among the first. As compared with the enormously increased consumption of other fixed or expressed oils, the use of castor oil in the United States is on a small scale; the annual consumption is measured by hundreds of thousands of gallons, where that of either cotton-seed oil or linseed oil amounts to tens of millions. However, the functions that castor oil performs in industry and in the arts are of great economic importance, as becomes apparent from a consideration of the varied uses to which its peculiar properties adapt it.

The entire European stock of the precious metals, coins, and plate, at the period of the discovery of America, was estimated by Gregory King, in 1696, at £45,000,000; and (for the same era) by Mr. Jacob, in 1820, at £34,000,000. Up to the year 1546 there had been obtained in America about twenty-five millions, and in Malacca and other places in Asia, say, ten millions more; altogether about thirty-five millions of pounds sterling. As a large portion of the first spoils were absorbed by the nobles and ecclesiastics, it is perhaps a liberal estimate to assume that the entire stock of money, both of silver and gold, billon and copper, in 1546, did not exceed, in nominal value, let us say £50,000,000. From 1546 to 1645, a period of one hundred years, there were obtained in America gold and silver to the value of no less than two hundred and ninety, and in Japan, eighty millions, together three hundred and seventy millions sterling. Assuming that fifty millions were retained in America, or lost by shipwreck and other casualties, and that one hundred and seventy millions were converted into plate, or employed in the arts in Europe, there would remain one hundred and fifty millions for convertion into coins. This would have enhanced the previous stock of money to three times, and it is believed that this is, more or less, what actually happened.—Del Mar's "History of Monetary Systems."

The fact that every cell or organ requires its food materials, or at least its nutrients, in liquid form, readily emphasizes the fundamental importance of those problems suggested by the relation of the plant to solutions. The mechanisms for absorption and the general and special diosmotic properties of the living cell, all of which have been studied with the most consummate skill, have yielded matchless results; yet the rewards for future research show at present no distinct limitations. It has not been possible to determine the nature of the plasmatic membrane which directly or indirectly possesses such marked powers of selection and accumulation. The conditions under which the activities of this membrane may be modified are but poorly understood; and it is, perhaps, quite beyond the present possibilities to determine the mechanism of this modification, for in that must be involved one of the most important vital activities of protoplasm. Perhaps, when much more data have been accumulated by a study of plants of diverse habitat, the conditions of this modification may be more clearly distinguished. It is known that continued endosmosis of a particular solute depends largely upon the use or transformation of this solute within, yet it is not always possible to demonstrate any change in the substance absorbed. In any event, it is necessary to ask further light upon the exosmotic resistance of the plasmatic membrane to the accumulation of turgor-producing substances, or, in other words, to a further explanation of what may be termed one-way penetration. To these phenomena the processes of excretion and secretion are closely allied, whether they are ultimately, periodically, or continuously the function of certain protoplasts.

ENGINEERING NOTES.

Closely related to the healthfulness, convenience, and cheapness of farm buildings is the right selection, care, and use of farm machinery. Studies of pumping machinery have shown that the most important factor in its successful use is the mechanical skill of the farmer, and we are beginning to understand that the increased complexity and cost of farm machinery make the education of the American farmer along these lines more and more désirable.

So long as street gas was the fuel *par excellence* for industrial engines, by reason of the facility attending its use, the applications of the explosion engine were limited to 50 to 75 horse-power, beyond which the cost of working was found to be excessive. Poor gas produced under pressure with the old apparatus of the Dowson type enabled one, it is true, to venture upon 75 to 100 horse-power, and even greater powers, with more practical results; but the complication of the gas-generating apparatus, the initial cost, and the space taken up by the producer-plant and engine rarely compared favorably with the steam engine and boiler. The latter, moreover, adapts itself better to every class of fuel, whether gaseous, liquid, or solid. Among solid fuels coal dust, as also peat, vegetable waste, straw, and sawdust constitute very advantageous fuels without requiring complicated and troublesome furnaces.

In order to compete successfully with the steam-engine, the explosion motor must be provided with cheap gas, easy of production by means of simple and economical apparatus. Suction gas-producers have decided the question for the industry in general, while the purifying and washing processes for blast-furnace gas, coke-oven gas, etc., have, in an unexpected manner, brought about the possibility of applying explosion engines to the greatest motive powers required in the metallurgical industry. While in electric lighting stations the steam engine, in spite of its great regularity in work, encountered a serious rival in the gas engine, the petrol engine has decided the question of road locomotion. Motoring, thanks to the wonderful attributes of small engines, has led to the application of internal-combustion engines for this purpose. Submarines have already been fitted with these engines, and it is safe to predict that at no remote date the explosion engine will take its place in the mercantile marine, side by side with powerful steam engines, for the propulsion of our vessels.

The object of all professional engineering schools is to send away thinking men with the equipment to become good engineers. A good engineer is a man who can do things in a certain field of labor rather than a man who knows a large number of facts in that same field, but is unable to use them. The technical school *can* teach students facts, and *may* train men to do and to think, but may fail utterly to do so. Much depends on the student's physical endowment, more depends on the methods of instruction, but most on the characteristics of the instructor and his individuality. This applies to such parts of the course of instruction as are dependent on the laboratory apparatus. If, by the use of apparatus, the student can acquire more than without it well and good, but the use of that apparatus will be better justified if, in addition, the student can be made to think more clearly, more boldly, more originally than without it, and finally when through the use of that apparatus he can be taught to do things. Then not only is the use of apparatus justified, but it must be regarded as indispensable, be the cost what it may. However, it is not sufficient that the above results are merely possible; it is even more necessary that the results be actually attained. If a result is possible, it can always be attained by proper methods.

Wrought-iron work, if not properly cared for in respect to painting, or under conditions otherwise bad, may be expected to rust at a rate which corresponds to the loss of ¼ inch on each surface in from fifteen to thirty years; but with proper care as to painting, and exclusive of exceptionally bad conditions, it does not appear to waste at any measurable rate. In some instances, upon scraping the paint from girders which had been in use for thirty years, the writer has found, beneath the original red lead, the metallic surface, bright and clean, showing no trace of rust. Of ordinary steel work the same cannot be said, the common experience being that mild steel is very liable to be attacked by rust. With common care in the bridge-yard during manufacture, such that with wrought iron no after trouble would be noticeable, steel is very liable to show, within a year of being built up, numerous little blisters on the painted surface; any one of these being broken away discloses a small rust-pit. This is more often seen on the flange surfaces (horizontal) than on web surfaces (vertical), but it is probable the position has little to do with the matter, and that it is rather due to the fact that rust has been earlier started on the flange-plates, upon being put through the drilling machines and inundated with slurry, which occurs only to a more limited extent with webs having fewer holes. The heads of steel rivets do not show this tendency to "pit," or to early development of rust. The riveting is about the last operation in making a girder, each rivet being freed of all rust by heating, and quickly coming under the protection of oil or paint. It may happen in this way that the heads of rivets on a girder may be exposed with-

out protection for as many hours only as the rest of the work for weeks, which fully accounts for the difference in behavior.

ELECTRICAL NOTES.

There are two money-saving possibilities for a printing telegraph system. It may increase the carrying capacity of the telegraph lines, and it may increase the output of the telegraph operators. That is to say, a printing telegraph may save telegraph wires, and it may save labor. In new countries, and especially big new countries like Russia, America, South Africa, and Australia, the saving of wire is the most important consideration. In fact, a telegraph line 1,000 to 2,000 miles long is so expensive that it pays to waste labor at each end if the carrying capacity of the line can be increased. It is for this reason that the Wheatstone automatic system, which is very wasteful of labor, is being increasingly employed on very long lines in Russia, South Africa, India, and other countries.

The importance of any discovery is measured ultimately by the material benefits which are derived from it. Estimated upon this basis the electric furnace may not perhaps be assigned a degree of importance comparable to that claimed by various other electrical devices. There is little exaggeration in the assertion, however, that if electric furnace development continues during the next two decades at a rate approaching the progress made in the past ten years it will have attained by that time a secure position among the most important of electrical appliances. To sum up the practical benefits, both immediate and remote, which it has already conferred would form the subject matter of a paper much more pretentious than is practicable here, yet it may be said to have only recently emerged from the experimental state.

The appropriate lighting of the Potsdamer Platz which is one of the most important and no doubt the most crowded thoroughfare of Berlin, afforded a rather difficult problem, which has just been solved satisfactorily, both from the point of view of the electrical engineer and the architect. After thorough preliminary investigations into the local conditions and density of traffic on that square, it was found advisable to concentrate the illuminants on two highly placed points, replacing the ordinary arc lamps formerly used by intensive "flame-arc" lamps, characteristic features of which are the juxtaposition of carbons and resulting downward emission of light. Two poles 21 meters in height were accordingly erected on the two islands, each of the masts bearing four 20-ampere lamps of about 4,000 normal candle-power each, giving a total effect of about 32,000 candle-power. The light is concentrated on a point 18 meters high. The intensity of the lighting thus obtained allows the existing eleven 12-ampere arc lamps to be dispensed with, while the square can now be inspected much more readily by passers-by. As the poles are used at the same time to carry the trolley wires of the tramway cars, four trolley masts formerly used could be removed.

The Bulletin of the Société d'Encouragement pour l'Industrie Nationale contains a short but interesting article upon the "Electrical Resistance of Steel." Following up some experiments made some time ago by Monsieur H. Le Chatelier, the author of this article—Monsieur P. Mahler—has carried out a series of tests on specimens of steel containing varying amounts of carbon, manganese, sulphur, phosphorus, and silicon. Generally speaking, he has established the fact—which, in truth, is what might have been expected—that the more impure the steel, the higher is its electrical resistance.

For example, in one of his sets of experiments he took five test-pieces, varying from soft steel with a breaking stress of 40 kilometers per square millimeter of cross-section, to hard steel with a breaking stress of 70 kilometers. The percentage of carbon varied from 0.16 per cent to 0.62 per cent, and of manganese from 0.70 per cent to 0.80 per cent. The observed resistance was 14.6 michrom-centimeters for the soft steel and 18.0 michrom-centimeters for the hard steel. M. Mahler found that the total resistance varied in accordance with the formula $R = 10 + 7C + 5Mn$; where C is the carbon, Mn the manganese, and 10 the resistance due to the iron and to the other impurities, such as sulphur, phosphorus, etc. The 7 and the 5 for carbon and manganese were the figures which M. Le Chatelier had found in his experiments. The coefficient 10 has been found by M. Mahler, and within the limits of his investigations the formula appears to give the resistance of any steel of known composition very fairly nearly.

There are discrepancies, which are sometimes on one side and sometimes on the other; but in a number of cases the calculated resistance was found to be the same as that which was obtained by measurement. Perhaps the balance lies rather in the direction of the coefficient, 10 being somewhat high, but this error is certainly on the right side. The ability to estimate the electrical resistance of steels of known composition within a reasonable degree of accuracy is highly important, having regard to the increasing use of steel rails for conducting electricity, and it would appear that in samples of metal known to be more or less oxidized or more or less gaseous, the actual resistance is less than what might be looked for if the above formula is taken as a basis. This means that, at any rate, the probabilities are that a calculation of the resistance is more likely to err on the high than on the low side.—The Engineer.

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